TECHNOLOGY DEPT.

TECHNOLOGY REVIEW

May 1956

A NEW DESIGN APPROACH . . .

. . . BEYOND-THE-HORIZON TRANSMISSION

BEYOND-THE-HORIZON TRANSMISSION

The newest military and commercial long-range communications systems are turning towards the advantages of "scatter" transmission. By transmitting *directly* to stations well beyond the horizon, scatter transmission systems eliminate the construction and maintenance of intermediate microwave stations and avoid cables and repeaters of wire systems, while retaining the wide bandwidths available at high frequencies. This *direct* transmission can span water or inaccessible terrain while giving predictably high signal reliability and freedom from interference.

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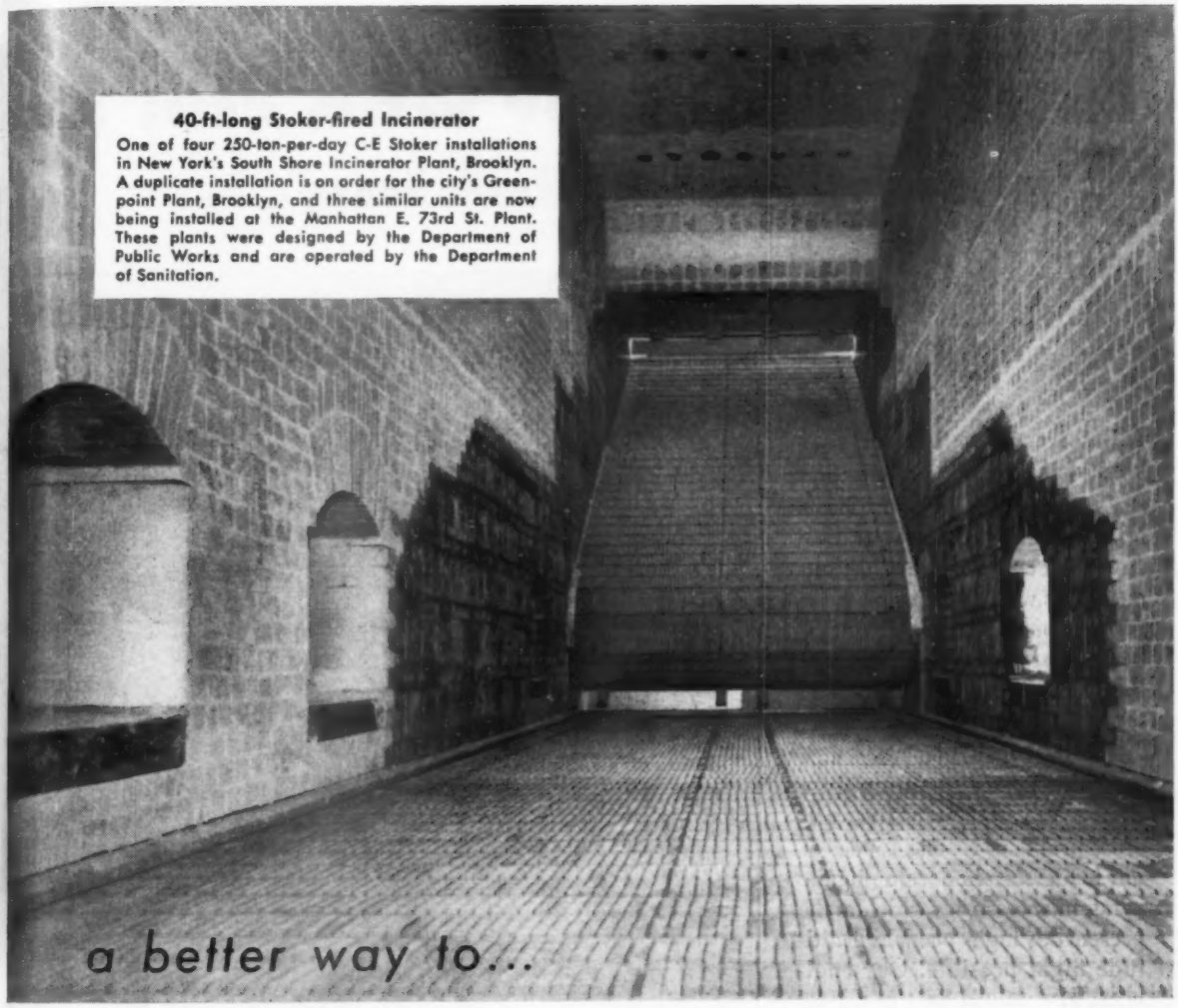
40-ft-long Stoker-fired Incinerator
One of four 250-ton-per-day C-E Stoker installations in New York's South Shore Incinerator Plant, Brooklyn. A duplicate installation is on order for the city's Greenpoint Plant, Brooklyn, and three similar units are now being installed at the Manhattan E. 73rd St. Plant. These plants were designed by the Department of Public Works and are operated by the Department of Sanitation.
a better way to...

GET RID OF REFUSE

REFUSE — its a big problem for cities and for industries, too. Usually, the best way to get rid of it is to burn it. That's what New York City does — using enormous stokers like the two shown in the incinerator furnace above, which can burn nearly two hundred and fifty tons of garbage and all kinds of refuse a day.

Four C-E stoker-fired incinerators like this went to work in the vast New York refuse disposal system two years ago. Since then, seven similar units have been ordered.

These stokers are specially designed to meet a special problem. But stoker units like this can burn mountains of *industrial* wastes, too. Moreover, combined with a waste heat boiler, they can be used to generate steam for space heating or process work.

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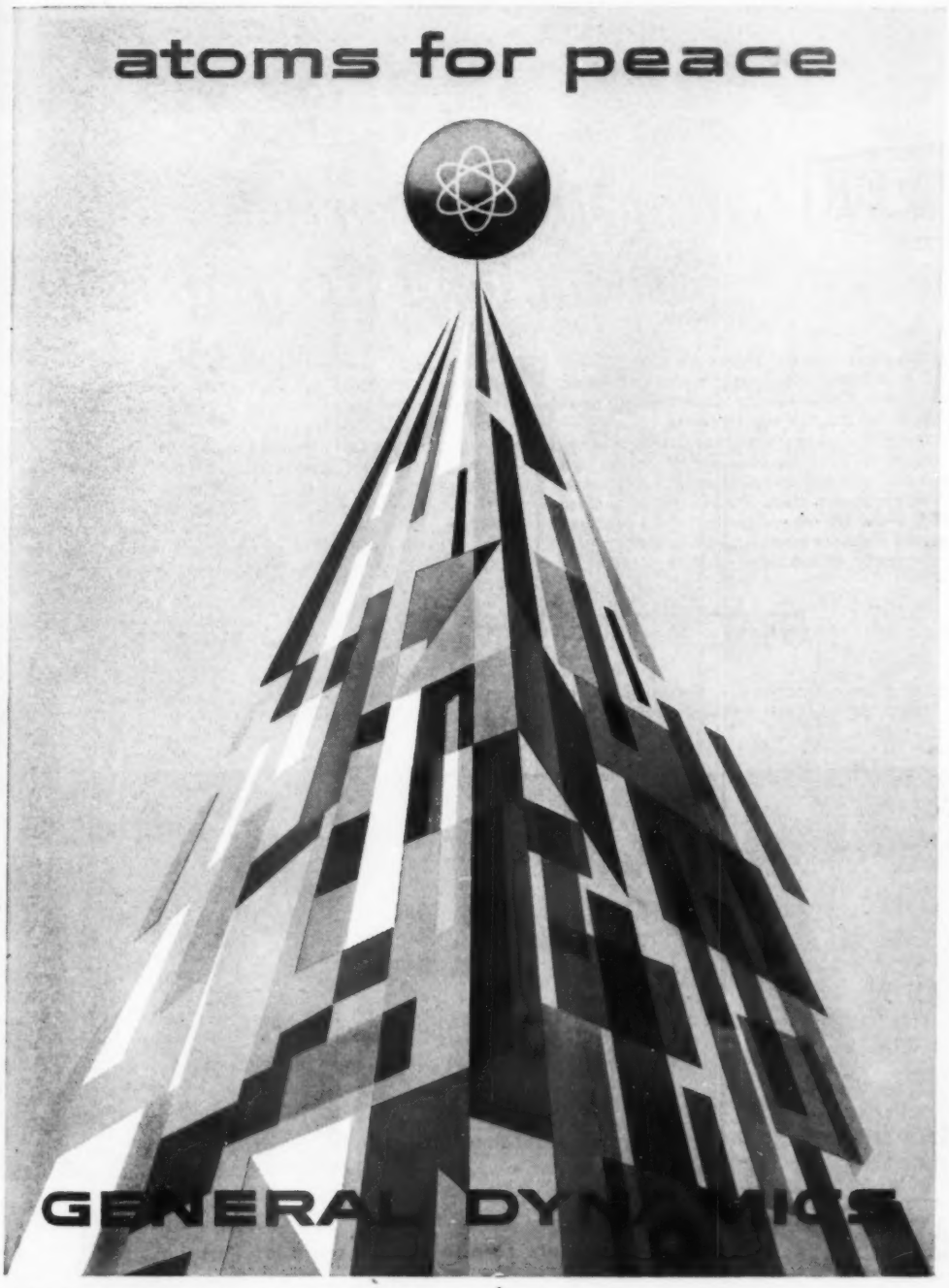

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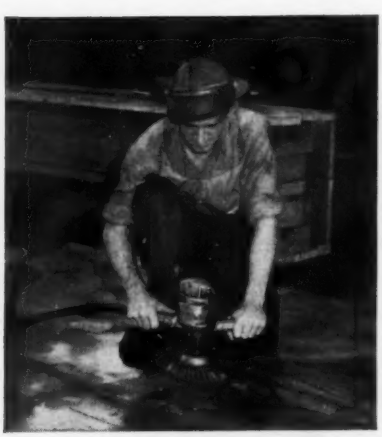

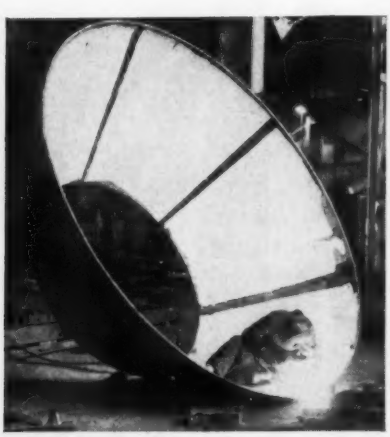

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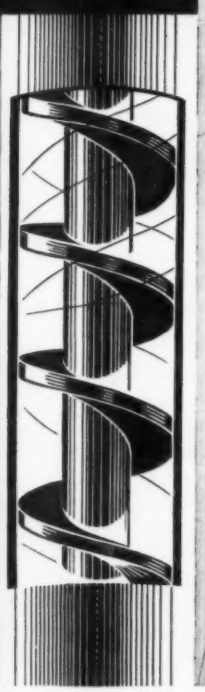

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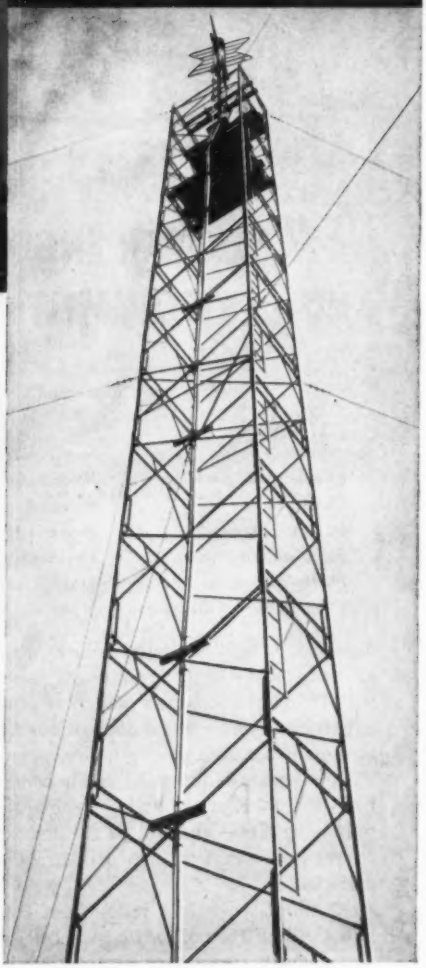

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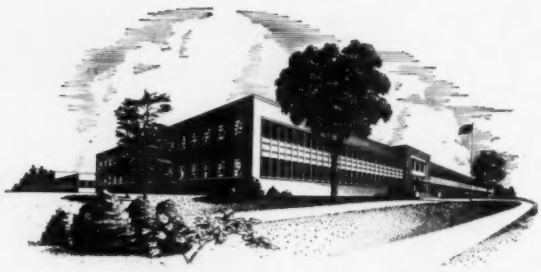

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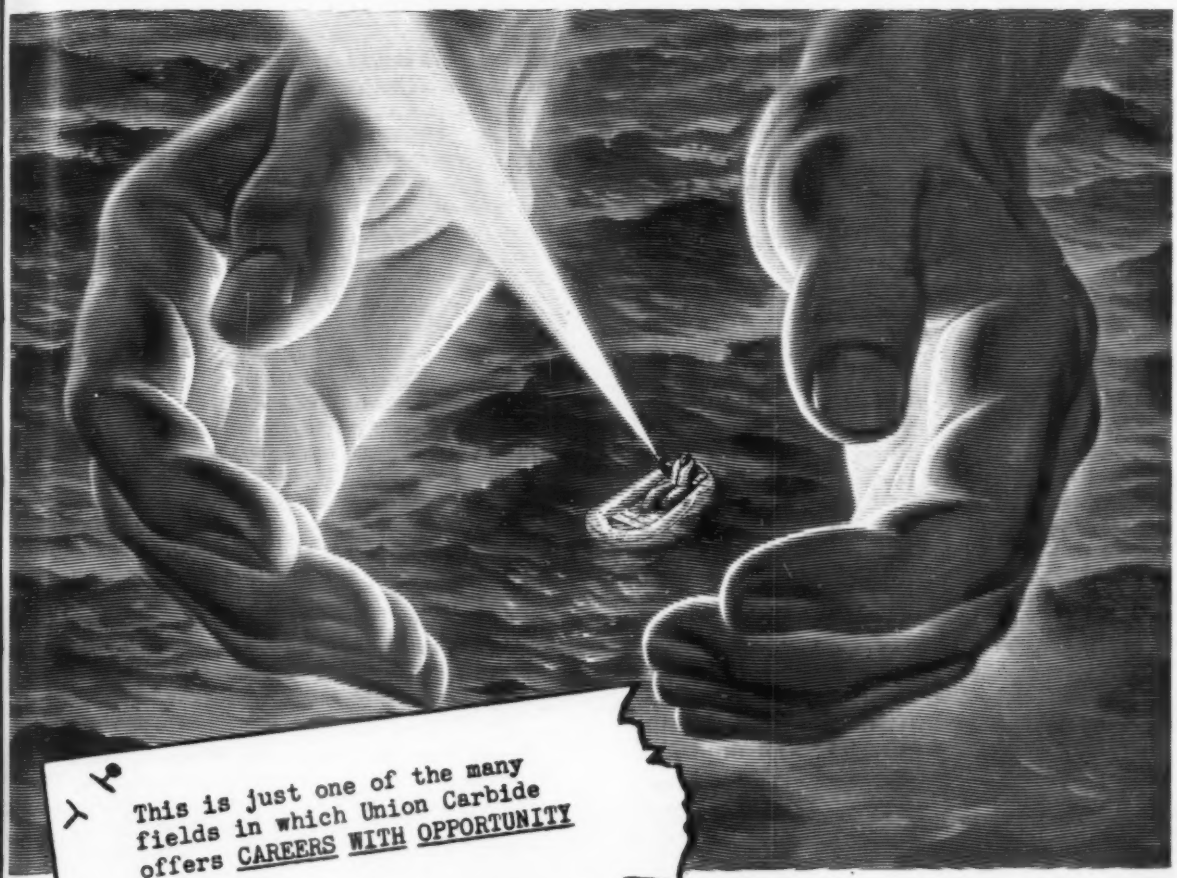
B-917

THE TABULAR VIEW

Technical Man Power. – Currently the nation is in a period of increasing need for technical man power, coupled with a dwindling supply of properly trained and available personnel. The article "Producing More Technical Man Power" (page 341) contains a number of pertinent suggestions by CLIFFORD F. RASSWEILER to alleviate the dilemma. Dr. Rassweiler is vice-chairman of the board and vice-president of the Johns Manville Corporation, and has been affiliated with that organization since 1941. For the preceding 17 years, he was a member of the Du Pont research organization in executive posts. Born in Polo, Ill., Dr. Rassweiler received the B.S. degree in chemistry from the University of Denver in 1920, the master of science degree from the University of Illinois in 1922, and the Ph.D. degree from Illinois in 1924. The University of Denver also awarded him the Sc.D. degree in 1947. Dr. Rassweiler was at the experimental station of E. I. du Pont de Nemours and Company in Wilmington from 1924 to 1927 and then went to Du Pont's Philadelphia Laboratory where he was assistant director in 1927–1933, and director from 1933 to 1941. He became director of research and development of the Johns Manville Corporation in 1941–1942, and vice-president in charge of research and development in 1942. Dr. Rassweiler's article was originally delivered as an address at the tenth annual meeting of the Armed Forces Chemical Association in Cleveland, Ohio, last June 17, and appeared in the July-August, 1955, issue of the *Armed Forces Chemical Journal* whence it was brought to The Review's attention by Per K. Frolich, '23.

Medical Engineering? – As far as we know, no one is proposing that colleges award the degree of medical engineer. But in "Union of Medical and Engineering Education" (page 345) DR. JAMES HOWARD MEANS, '06, calls attention to the excellent science instruction now being offered by engineering colleges, which provides first-class training for those intending to follow careers in medicine. Dr. Means envisions the possibility that institutes of technology could well establish programs that would qualify students to enter medical school at about the third year. The more medicine depends upon modern scientific instruments and techniques, and the more M.D.'s engage in biophysics, biochemistry, research, and the like, the more attractive his proposal becomes. Dr. Means studied biology at M.I.T. as a member of the Class of 1906, received the A.B. degree from Harvard College in 1907, and the M.D. degree from Harvard Medical School in 1911. He was medical intern at the Massachusetts General Hospital from 1911 to 1913. He studied at the University of Copenhagen and in the Department of Physiology, Cambridge, England, and was Henry P. Walcott Fellow in Medicine at Harvard University from 1913–1916; and, during the tenure of this fellowship, established a clinical research laboratory at the Massachusetts General Hospital. He served in France with the Medical Corps in World War I, and returned to Massachusetts General Hospital. In 1923 he was appointed Jackson Professor of Clinical Medicine at Harvard and Chief of Medical Services at M.G.H. During World War II he served as chairman of the Subcommittee on Clinical Investigation of the National Research Council, and as adviser to the Office of Scientific Research and Development. Upon his retirement from the Massachusetts General Hospital and Harvard Medical School, he was appointed staff physician of the Institute's

(Concluded on page 332)



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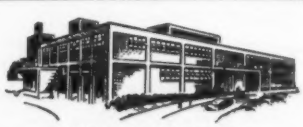
THE TABULAR VIEW

(Concluded from page 330)

Medical Department. At the present time he is Jackson Professor of Clinical Medicine, Emeritus, and honorary physician, Massachusetts General Hospital.

Help Wanted. — Methods which might be used to increase the supply of technically trained man power, and also to improve the quality and quantity of teaching in science subjects in secondary schools, were discussed at the St. Louis Regional Conference on February 4 by JOSEPH W. BARKER, '16. His comments appear (page 349) under the title "Shortage of Engineers and Scientists." After a year of study at the University of Chicago, Dr. Barker came to M.I.T. where he received the S.B. degree in 1916 and the S.M. degree in 1925. In addition, he has doctorate degrees from Bucknell University, Northeastern University, Case School of Applied Science, Union College, University of Rochester, and Muhlenberg College. He was a member of the M.I.T. Department of Electrical Engineering, 1925–1929; head of the Department of Electrical Engineering at Lehigh University, 1929–1930; and dean of the Faculty of Engineering, Columbia University, 1930–1946. During World War II he served as special assistant to the Secretary of the Navy, and since 1945 has been chairman of the board and president of the Research Corporation, New York City.

Report from the West. — On March 17 some 400 Alumni and friends of Technology attended the West Coast Regional Conference at Los Angeles where a notable program of speakers outlined current progress in science, engineering, and industrial management. A report on this meeting (page 351) is provided by DAVID O. WOODBURY, '21. Mr. Woodbury received the A.B. degree from Harvard College in 1918, an A.B. degree from Leland Stanford University in 1920, and the S.B. and S.M. degrees from M.I.T. in 1921. He has also studied at the School of Journalism, Columbia University. His early professional career dealt with telephone engineering, but his interests later led him into writing science articles for newspapers and magazines. Since 1929 he has been a free-lance interpreter of science. The photographic illustrations were made by his son, Peter Woodbury.



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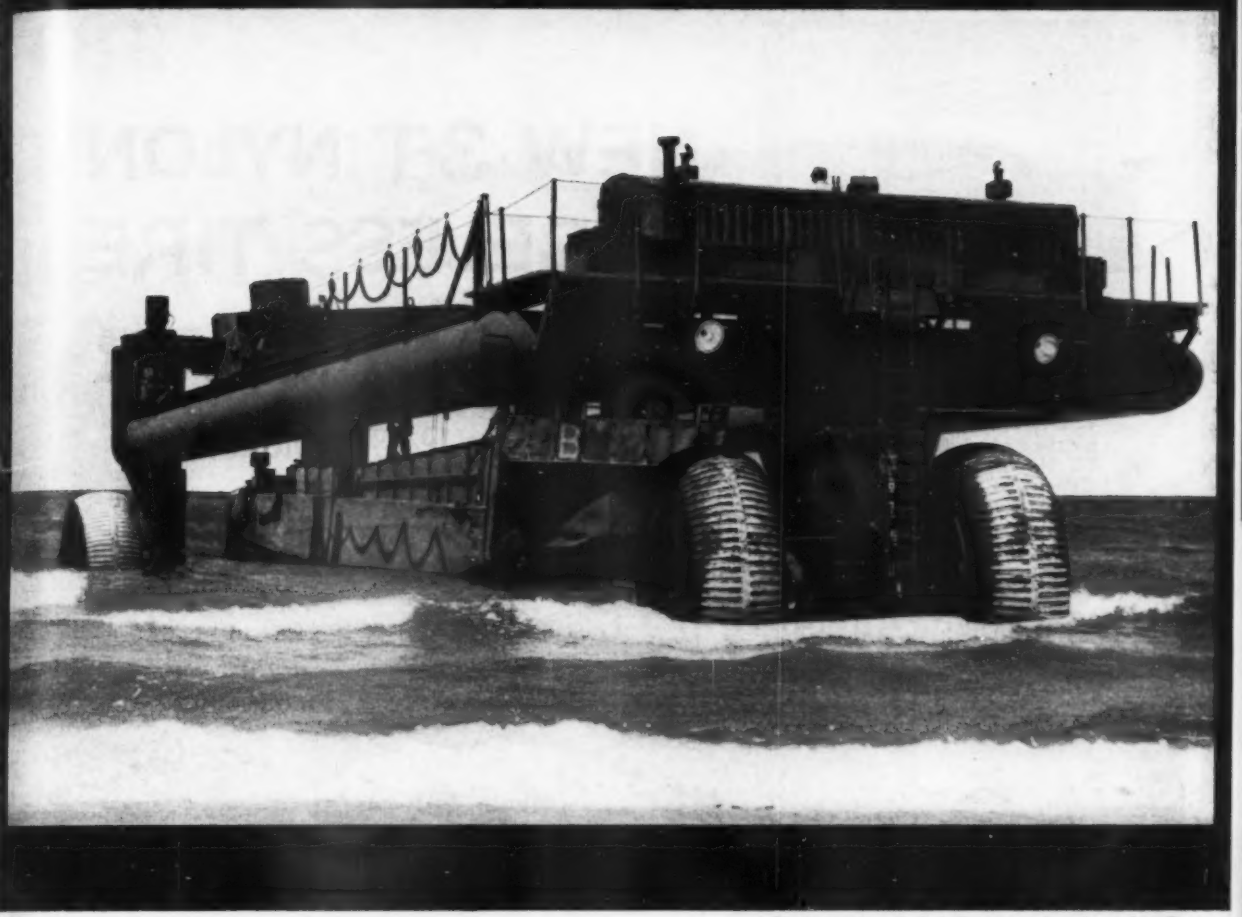

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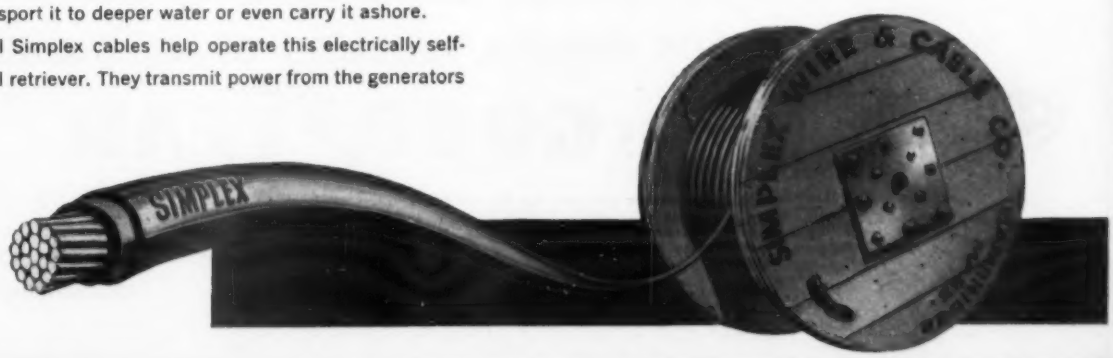

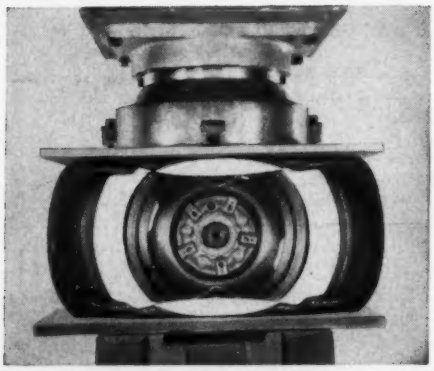

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THE TECHNOLOGY REVIEW

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Raymond E. Hanson

New Hampshire's pines guard tree-skirted lake at Chocorua.

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The Trend of Affairs

Pestiferous Pets

MODERN public health is much concerned with preventing the spread of infectious diseases from man to man, but also gives attention to preventing passage of infections from animals to man. As has been pointed out in the pages of The Review,* a United Nations report lists no less than 86 animal diseases transmissible to man. Of these, 10 are reported to be of such major significance as to merit intensive study.

Need city dwellers be at all concerned about contracting animal diseases? As urbanites do not come near cattle, they need not worry about getting undulant fever. Unless they be equestrians who ride the bridle paths in parks, they do not come in contact with horses which might infect them with equine virus encephalitis. If they do not hunt they do not encounter rabbits or other wild rodents from which they might contract tularemia. But alas! Urban man has extensive and intensive contact with pets.

Indeed, one of the major animal diseases transmissible to man is the infection that causes parrot fever in parakeets and pneumonia in man. The gravity of this disease led some states to attempt its exclusion from their territory by forbidding the importation and sale of parakeets. Such quarantines proved ineffective because, it was found, other birds that fly freely, and have no regard for state lines, are capable of conveying the infection. Therefore parakeets are now sold and shipped freely, and these engaging little birds have gained a tremendous vogue, particularly since World War II.

But the pets with which urban folk have most contact are dogs and cats. No family home is quite complete without one or both of these animals, unless perchance they had been found to be the cause of Junior's allergies. How do dogs and cats stand as vehicles of diseases that can strike man? These pets suffer no less than 44 diseases transmissible to the human being. Seven of these are considered to be serious, 25 less important, and 12 rare. Twenty-two of these infections are shared by the cat and the dog; 15 affect the dog alone, 7 the cat alone. Included is a broad spectrum of bacterial, viral, and protozoan infections, and infestations by parasites. Avenues of transmission are contact, swallowing, inhalation, skin abrasions, or the mediation of insects such as fleas or ticks.

What can be done about this threat to health? People will not give up pets. Even where parakeets were banned, there was a thriving black market and the birds were common. Certainly human beings, even though they benefit from the myriad products of the Twentieth Century, are not inclined to forego cats and dogs, whose companionship they have enjoyed since the dawn of civilization.

Indeed, there is no need for the abolition of pets. The spread of disease from animal to human being may be prevented the same way as the spread of disease from man to man; by effective sanitation. No matter how much an owner may love a pet, he should limit physical intimacy with the animal and wash his hands thoroughly after handling it. Young children especially need supervision in their contacts with pets; they lack the aesthetic inhibitions that help guard adults against contact with the saliva and excreta of animals. Pets should have their own eating dishes, or else the dishes should be sterilized after use. Pets should be kept free of fleas and ticks that might convey infection. Animals should not be allowed to defile beaches or other areas where people go barefoot, as at least one important animal intestinal parasite enters the human body through the foot. Thus, although they are potentially pestilential, feline and canine pets may be enjoyed with impunity by man so long as owners observe a sensible degree of sanitation.

* "Animals Versus Man," The Technology Review **56**:390 (June, 1954).

Highway Bridge Vibration

THE movement of traffic across highway bridges induces vibrations which are important for two reasons: (1) the stresses in the structure are increased above the normal static values, and (2) persons on the bridge may find the vibration objectionable. The first effect is, of course, dangerous since excessive vibrations may impair the safety of the bridge. The second effect, while perhaps not dangerous, is important since it may result in public distrust of the structure.

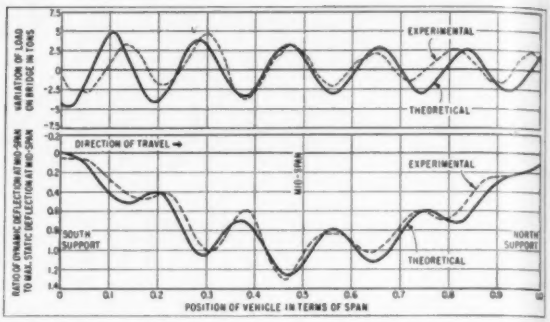
Although bridge engineers have recognized this problem they have not had available the theoretical means to predict accurately the dynamic behavior of bridges. As a result, bridges have been constructed which proved to be unsatisfactory. In other cases, engineers have discarded what would have been economical designs because of an unwarranted fear of excessive vibrations. Bridge engineering design would be considerably advanced by a theoretical procedure that would permit bridge vibration to be predicted with accuracy.

During the past two years the Structural Division of the Department of Civil and Sanitary Engineering has been conducting research on the subject. Early exploratory field tests indicated that the dynamic behavior of the vehicle itself was of primary importance in highway bridge vibration. This behavior is largely determined by the character of the roadway surface. It was further indicated that, in most cases, surface roughness on the approaches to the bridge contributed more to the vibration than did irregularities on the structure itself.

A method of analysis has been developed which includes the dynamic characteristics of the vehicle as well as those of the bridge. The method was verified by carefully controlled laboratory tests on bridge models.

A series of field tests recently completed permitted a comparison of the theoretical results with the behavior of actual structures. These tests, which were made on typical highway bridges having spans of about 90 feet, involved the measurement of the dynamic bridge deflection due to the passage of a 20-ton vehicle at various speeds. The vehicle itself was instrumented and continuous records were obtained by a portable oscillograph mounted in the vehicle. The measurements taken were the bending strain in the axle and the vertical acceleration of the axle mass. By proper combination of these readings, the actual force applied to the bridge could be obtained at any time. The mid-span deflection of the bridge was recorded simultaneously.

Typical experimental results are shown in the illustration. The upper curve shows the variation in the force applied to the structure by the vehicle as it crossed the span. The lower curve shows the bridge deflection during the same period of time. Also shown in the illustration are theoretical results based upon an assumed initial vibration of the vehicle on its own springs, which is determined by the roughness of the approach roadway. The differences between the theoretical and experimental curves of load variation are of secondary importance and are due primarily



Comparison of theoretical and experimental mid-span deflections of Townsend Main Street bridge. Bridge has span of 88.67 feet and static deflection of 0.162 inch. Vehicle producing vibrations shown above was 20-ton truck traveling at 37 feet per second.

to surface roughness on the bridge, which was not considered in the theoretical computations. The two curves of bridge deflection are in close agreement.

The experimental results indicate that the theory provides an accurate method for the prediction of bridge vibrations. Theoretical data are now being obtained by analogue computer for vehicles of various characteristics and bridges of various types of spans. When completed, this data can be applied directly to the design of highway bridges.

This project is under the direction of John M. Biggs, '41, Associate Professor of Structural Engineering, and is being conducted with the co-operation of the Department of Public Works of the Commonwealth of Massachusetts.

Radiation Recapitulation

IONIZING radiation, useful to mankind ever since Roentgen discovered the x-ray, has been finding application of an ever-accelerating rate since the advent of nuclear fission. Thoroughly established uses of ionizing radiation are in the diagnosis and treatment of disease, tracer studies in biochemistry employing radioactive elements, the forcing of mutations, elimination of static electricity, detection of flaws and foreign materials, gauging of thickness, location of leaks, and studies of friction and lubrication.

Still in a developmental stage but showing much promise of ultimate practical value, is the preservation of foods by means of ionizing radiation. Pioneer work in this area, done at the Institute by the Department of Food Technology co-operating with the Department of Electrical Engineering, revealed that foods in sealed containers may be sterilized by irradiation, with only negligible increases in temperature. Thus is accomplished indefinite preservation of the foods, without the particular adverse changes in flavor, color, and texture resulting from the high temperatures required for heat sterilization, as in canning. Radiation sterilization of foods has indeed been called "the first new basic method of food preservation since Appert's discovery of canning."

Ionizing radiation has also been found capable of extending the storage life of non-sterile foods, such as meats and vegetables held under refrigeration but not frozen. Thus a recent publication from the Institute's Department of Food Technology announces

that treatment with high-voltage cathode rays, at dose levels in the order of 1.0×10^6 or 1.5×10^6 Roentgen equivalent physical, considerably postponed spoilage of spinach, fresh pork sausage links, sausage patties, ground beef, and frankfurters held at refrigeration temperatures. This work was done by Professor Bernard E. Proctor, '23 (Head of the Department of Food Technology), John T. R. Nickerson, '32 (Associate Professor of Food Processing), Joseph J. Licciardello (technical assistant), Samuel A. Goldblith, '40 (Associate Professor of Food Technology), and Ernest E. Lockhart, '34 (Associate Professor of Food Technology), who acknowledge the co-operation of Professor John G. Trump, '33, of the Department of Electrical Engineering, and Kenneth A. Wright, '47, of the Division of Industrial Coöperation, in making available the Van de Graaff accelerator for production of the radiation employed and also for providing counsel on the research.

Commercial use of ionizing radiation in the processing of foods must await general availability of the needed equipment, categorial proof of harmlessness to the consumer, and elimination of certain changes, such as off-flavors, caused by the irradiation. The group at the Institute found that addition of harmless salts such as sodium ascorbate, sodium fumarate, and monosodium glutamate served to obviate the characteristic irradiation off-flavors. Frank J. McArdle and Norman W. Desrosier, at Purdue University, have announced methods for determining molecular changes in proteins of foods caused by irradiation; and employing these methods have observed that such undesirable changes may be minimized by adding ascorbic acid before irradiation.

Thus developments in the food field are serving to broaden biological application of ionizing radiation. A quite novel biological use of radiation has just been announced; extermination of an insect pest. This method has made possible the total eradication from the West Indian island of Curacao of a serious livestock pest, the screwworm fly. This insect lays eggs in open wounds of cattle. The hatched larvae feed upon the exposed flesh, causing agonizing pain, sometimes even destroying the cattle.

It is known that the female screwworm fly mates but once. Hence any female that mates with a sterile male never produces young. On the basis of this knowledge, the island of Curacao was saturated with laboratory reared male flies made sterile by exposure to ionizing radiation. By trial and error it was determined that a release rate of 400 sterile males per week per square mile served to completely prevent reproduction by this fly. In this way the pest was completely eliminated from the island.

The screwworm fly is a serious pest of livestock in the United States, particularly in the warmer southern areas. Its elimination by irradiation sterilization of males would be much more difficult here, because this country is not a small and isolated area like the island of Curacao. Nevertheless it appears that ionizing radiation has developed one more biological application of utility to mankind, that may in small measure counterbalance the terrible threat of radiation damage from atomic war, and also the danger of human genetic damage from the ever-mounting background radiation now arising from many sources.

More Oil: Less Water

MANY oil wells are "submarginal" in the sense that income from oil royalties is insufficient to support cost of operation and yield a satisfactory return on the investment required to drill and operate the well. For such wells, a minor stimulation of production will often make the difference between economical and uneconomical operation and will allow production of oil which, under normal circumstances, would be left underground. It is very much worthwhile, therefore, to explore those techniques that promise improved rates of petroleum production.

In the primary recovery of petroleum from water-drive reservoirs, and in secondary recovery from water-flood projects, the efficiency of oil production is often greatly reduced by the premature intrusion of water into the oil-bearing stratum, so that wells produce water and oil simultaneously in varying degrees. Frequently loss of oil production appears to be caused by encroachment of water into the oil-bearing stratum immediately below the well. As a result of pumping oil to the surface, low pressure near the well-bore is accompanied by a rise in the water table at the well-point. As shown in Fig. 1 (page 340), the water table assumes a characteristic conical shape, with its apex at the well-bore. In addition, capillarity causes the water cone to rise to a higher level than that predicted by simple hydrodynamic considerations. There appears to be promise of increasing oil productivity if economical means for alleviating water-coning can be achieved by altering the properties of the formation surrounding the well-bore.

Studies indicate that the forces required to suppress the water cone are small. If it should be economically feasible to prevent formation of the water cone, or to substantially reduce the extent of its rise, enhanced oil productivity might be expected to result. Research recently conducted at the Institute has been directed to exploring the possibilities of minimizing or eliminating water-coning by chemical treatment of the formation adjacent to the well-bore, in order to alter the capillary forces acting at the oil-water interface, as shown in Fig. 2. The research has been conducted by Alan S. Michaels, 2–44, Assistant Professor of Chemical Engineering and Associate Director, Soil Stabilization Laboratory, with the assistance of two former students of M.I.T. – Richard I Bergman, '55, and Daniel L. Brown, '55 – the latter of whom is at present at the Institute in the Soil Stabilization Laboratory.

Basically the idea behind the Institute's research is to inject into the well-bore a relatively small quantity of a treating agent which adsorbs firmly on the formation surface around the well-bore and which changes the oil-water-solid contact angle so that oil, rather than water, wets the surface around the well-bore. By such a technique, oil, rather than water, wets the surface in what has been called "reverse wetting" of the porous formation.

A laboratory apparatus, consisting of a cylinder of 20–40 mesh Ottawa sand to which oil (kerosene) and water were fed peripherally and from the center of which the fluids could be withdrawn at a controlled rate via an axially located perforated tube, was used for this study. The oil-to-water ratio in the produced

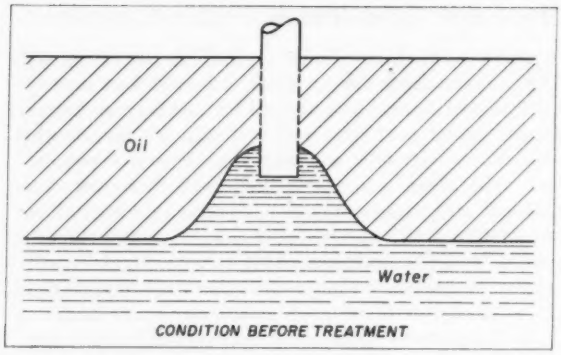


Fig. 1. Naturally occurring water cone, at oil-water surface near well-bore, allows water to be pumped along with oil.

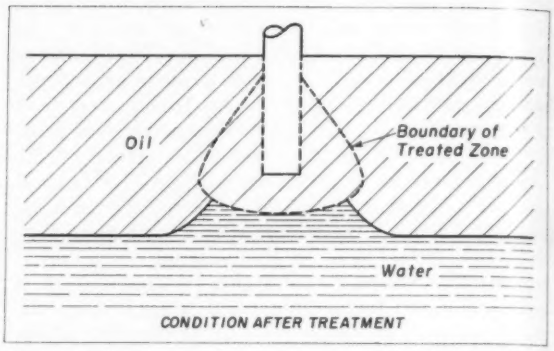


Fig. 2. Reduced water cone, after treatment with reverse-wetting additives, increases rate of oil production.

fluid was measured as a function of flow rate and location of the oil-water horizon in the cylinder, with the sand untreated (that is, water-wet). Small quantities of dilute (50 parts per million) aqueous solutions of two reverse-wetting additives (octadecyl amine acetate, and dioctadecyl dimethyl ammonium chloride) were then forced out into the sand via the perforated tube, and the oil-water ratio redetermined at varying flow rates and interface locations. It was found that, under conditions where prior to formation treatment no oil was delivered, treatment with these additives resulted in the production of fluid containing as much as 67 per cent oil, the oil-to-water ratio decreasing with increasing flow rate. Under conditions where, prior to treatment, the produced fluid contained 24 per cent oil, after treatment as much as 100 per cent oil was delivered.

The results of this study suggest that, for very highly permeable, sandy formations, treatment of coned-out wells by injection of dilute aqueous solutions of reverse-wetting additives, in sufficient quantity to alter the capillary forces in the vicinity of the well-bore, may be useful in preventing or minimizing water-intrusion by coning.

Cultural Achievement

WHEN Louis Pasteur established the modern science of microbiology during the latter half of the Nineteenth Century, one of his most fundamental contributions was the development of methods for growing micro-organisms in pure culture. In nature, all forms of life exist in heterogeneous mixtures; this is especially true of bacteria, molds, yeasts, and such microscopic forms. Manifestly, it is difficult to study microbes as members of complex and variable mixed populations. Pasteur overcame this obstacle by developing methods whereby a given strain of micro-organism could be isolated from all others, and studied in pure culture.

Pasteur's methods for establishing pure cultures had one serious shortcoming that has since been overcome. He proceeded on the assumption that "colonies" of micro-organisms, grown on solid nutrient media, represented pure strains. It was subsequently learned that, as a result of genetic variations of micro-organisms that arise from time to time through mutation, a colony may include several somewhat different, if closely related, strains. This observation led to development of means for starting pure cultures of microbes from single cells. Isolation of single cells for this purpose is accomplished by extraordinarily delicate micromanipulation apparatus, capable of grasping a single microbe despite its minute size, generally in the order of a few microns in diameter.

Methods for maintaining micro-organisms in pure culture for study purposes are the basis of much of modern medicine, public health, food technology, and the fermentation industries. It is startling to learn that this great scientific accomplishment of man has long been within the powers of certain species of ants. These insects maintain fungus gardens in their nests as a source of food. The substrate on which the gardens grow consists of leaves that the ants have gathered and triturated into small particles. Only a particular species of fungus is acceptable to the ants as food; and their fungus gardens represent as pure and unmixed a growth of this fungus as any meticulously maintained modern laboratory culture. The fungus has never been observed anywhere but in the ants' nests. Purity of the ants' cultures depends entirely upon the animals' presence; if they are removed from their nests, their fungus gardens are quickly invaded and overgrown by fungi of other species and by bacteria. Conversely, if the fungus on which the ants feed is established in the laboratory on a culture medium, and this growth then surrounded with colonies of bacteria and of alien fungi, ants placed upon this culture will maintain their favorite fungus in pure and flourishing form, even though they clamber over the bacteria and the other fungi in their peregrinations about the culture plate.

How do the ants accomplish this extraordinary feat of maintaining their cherished food fungus in pure culture despite all sorts of adversity? Apparently some form of antibiosis is involved; some chemical substance may be present that prevents growth of all micro-organisms except the desired one. The nature of such an antibiotic and a possible source are unknown, although it has been postulated that the digestive tract of the ants may generate the material. Thus the pure culture methods of ants probably differ fundamentally from those employed by human microbiologists.

More Than Any Other Nation, the United States Depends on Scientists and Engineers to Maintain Its Way of Living. Here Are Some Suggestions for

Producing More Technical Man Power

By CLIFFORD F. RASSWEILER

So much has been written and said about the shortage of scientific and engineering man power that it seems superfluous to start this talk by presenting any figures to substantiate the conclusion that there is serious need for active measures to increase the production of such technical personnel.

So far as industrial needs are concerned, almost everyone here must be personally conscious of the impossibility of hiring enough technical man power this year to provide for the needed research and engineering activities which are essential for maximum industrial progress. As regards our situation versus Russia's, the most commonly quoted and accepted figures are that our annual need for new engineers lies between 30,000 and 40,000. Against this need we produced 50,000 in 1950 without any evidence of surplus, but our production since has dropped annually until this year we will graduate only approximately 22,000 engineers. In the meantime, in 1955, Russia had reached an annual production of 40,000 engineers by intensive development of scientific and engineering schools and concentration on the teaching of mathematics and science in the secondary schools. There is every evidence that a large percentage of these men have been well trained by Russia's educational system.

However, there are no really adequate figures regarding the total number of available scientists and engineers in comparison with industry and teaching demands, and attempting to forecast in this area is difficult. As late as 1949, a government publication on occupational opportunities predicted an oversupply of engineers and rated attractiveness of engineering careers at a rather low level. There is a very considerable tendency to think of our present shortage of technical man power as a short-time problem involving the discouraging government forecast, the low birth rate of the 1930's, excessively high industrial demand due to boom conditions, and the drain of military needs upon available supply.

On the other hand, there is considerable justification for the belief that our present critical situation is at least partly due to long-range educational and economic trends, which are not likely to be reversed in the foreseeable future. The shortage of technical man power has now been with us for almost 15 years. We blamed it first on draft policies during World War I and the failure to continue training technical people during the war years. Yet the great upsurge in college enrollment which followed the end of the war did not fill up the deficiency in technical man power which had grown so sharply during the war. Now we are tending to blame the continuing shortage on low college enrollments due to the low birth rates of the 1930's. All of the factors referred to in these explanations of course have an important effect upon our situation; but behind them lie certain long-range changes in our educational and economic situation which may be more basic causes for our difficulty. It is about the effect of these situations on our technical man-power supply that I would like to speak here.

Dael Wolfle, Director of the Commission on Human Resources and Advanced Training, in his book *America's Resources of Specialized Talent*[*] gives some interesting figures on the percentage of four-year college graduates who have specialized in different fields in terms of averages for five-year periods since 1900. These figures show that, during a period in which science and engineering have come to be of increasing importance in our industrial economy and our national defense, there has not been a corresponding increase in the interest of college students in these subjects.

Specialization of college students in chemistry, physical science, and mathematics, which provide the background training for our industrial research progress, reached its maximum in the 1911–1915 period when 8.9 per cent of the four-year degrees awarded in the United States were in these specialties. Since that time the interest of college students in these subjects has decreased in an almost even trend, until in the 1951–1953 period only 4.4 per cent of the degrees granted were in these specialized fields. During this period, expenditures for physical research in this country grew from less than 100 million dollars per year to approximately four billion dollars per year. Yet during the period of this phenomenal growth in this activity, interest of college students in preparing for this type of work, or for teaching to prepare others for this type of work, has dropped 50 per cent. The reports of the Office of Education, now a part of the United States Department of Health, Education and Welfare, on "Earned Degrees Conferred by Higher Educational Institutions" give us detailed figures on an annual basis since 1949. These figures show that during this period the percentage of degrees awarded in the physical sciences has continued its slow decrease.

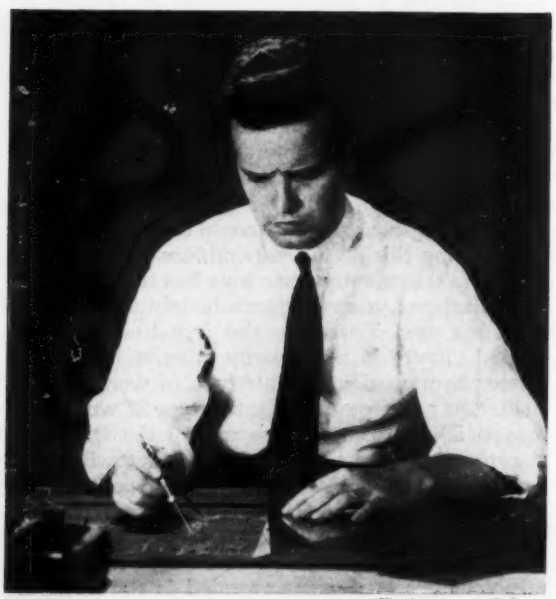
[*] New York: Harper and Brothers, 1954.

Harold M. Lambert

It is the scientist who spends his evenings reading scientific literature. . .

It is interesting that during this same period, from 1911 to the present, the percentage of four-year degrees awarded for specialization in the fields of social science and psychology has increased from 7 per cent to 13.2 per cent. In other words, during a period in which we have been disturbed by the thought that preoccupation with physical science was draining off the best of our college brains, what has actually happened is that interest in physical sciences has been cut in half, whereas interest on the part of college students in social sciences has doubled.

The figures on engineering do not show as clean-cut a trend as the figures on physical sciences. In the period of 1916–1925, covering World War I and its postwar adjustments, the percentage of four-year degrees awarded for specialization in engineering averaged 9.7 per cent. In the corresponding period from 1941–1950, the percentage was 10.1 per cent. In the intervening years, the percentage of degrees which were awarded to engineers lay between 7 per cent and 8 per cent. It would appear, therefore, that the interest of our college population in engineering subjects has shown practically no increase during a period in which our industries have been converted largely to mechanized production, and during which we have seen spectacular increases in the importance of the electrical, the automotive, and the aviation industries based largely on engineering effort. The more recent trend, however, is shown most clearly by some figures in Dael Wolfle's book showing the percentage of four-year degrees granted to male graduates since 1947 which have been for specialization in engineering subjects. His figures show that from 1947–1953 the percentage has dropped in every year, making a relatively smooth trend line from 18 per cent in 1947 to 12 per cent in 1953. The bulge of 1950 in engineering degrees awarded was the result of high total graduation, not of increased interest in engineering. The detailed report of the Office of Education gives the further interesting information that this decrease in interest in engineering subjects has been sharpest in the fields of aeronautical, electrical, and mechanical engineering, where one might have expected the interest to have been greatest. In each of these three fields, percentage of degrees awarded has dropped more than 50 per cent since 1949.



H. Armstrong Roberts

It is the highly trained engineer who takes a brief case full of blueprints home to work on over the week end. . .

It is obvious that we have been saved from what might almost be a catastrophe by the fact that the decreasing percentage of interest in physical sciences and engineering on the part of our college population has been compensated by the great rise in over-all college attendance. We are now in a particularly critical situation, because a simultaneous decline has been occurring during the last three years both in interest in these subjects and in total over-all college enrollment. It is possible that all we have to do is to struggle through to the point where total college enrollments will expand again as a result of the high birth rates of the 1940's. But the extent to which interest in science and engineering has failed to keep pace with its growing importance in our industrial civilization is too serious to be passed over without careful study.

There is a growing realization that the root of our trouble lies in long-range changes which have taken place in high school education. Both decreasing interest in technical subjects and inadequate production of technical man power start with situations now facing our young people when they first enter senior high school.

There will always be a certain percentage of students entering high school who know definitely that they are going to college and even that they are definitely going to become scientists or engineers. Students with such definite convictions, almost regardless of where they live, can secure high school training which will qualify them for college admission and eventually for college degrees in their chosen specialties.

However, the young people with whom we are concerned are those who enter high school without any definite conclusion as to what profession they in-

tend to eventually follow, and even without any definite fixed decision as to whether they do or do not intend to take a college education. Among these are many young men who could become scientists or engineers but who also might become salesmen, ministers, or skilled mechanics. Our difficulty stems partly from the fact that the unconscious pressures to which they are subjected by our present high school educational system tend to turn them away from science and engineering, even though these might be very satisfactory professions to enter.

When a young man enters high school, his obvious primary objective is to get a high school graduation certificate. If he is intelligent and aggressive, he has a secondary objective of wanting to make a good scholastic average while doing so. If he definitely wants to go on to college, it becomes vitally important that this scholastic average be in the upper quarter or upper 10 per cent of the class if he is to get into the college of his choice. Also, he has the natural objective of wanting to take part in at least a reasonable amount of extracurricular activities; and the more intelligent he and his parents are about his eventual development, the more likely he is to feel impelled toward establishing some such suitable balance. Also, being a natural human being, he sees no reason why he should work any harder than necessary to achieve these objectives.

In order to achieve these generalized objectives, a student quickly finds that it is expedient to avoid science and mathematics as far as possible. This is particularly true for the earnest student striving to make high scholastic averages, unless he happens to be that rare creature who has mathematical aptitude. Avoiding science and mathematics is an almost inevitable decision for the student who is trying to find the easy way to get a high school certificate or to get into a college of his preference.

If you have any question about this, ask your teenage children or the children of some of your friends what are the "snap," or more colloquially called "gut," courses in their high schools or colleges. You will not find algebra, geometry, calculus, chemistry, and physics included. In the old days, where the curriculum demanded courses which taught exact and disciplined thinking, the students were forced to take a considerable amount of this type of work. Now, however, with the liberal choice of studies and relaxed college requirements, the easiest way to get through high school and into college is to avoid as many of these subjects as possible. As a result, an increasing number of students entering college do not have the high school training necessary to qualify them for major work in science or engineering. In fact, college advisers say that it is very common to ask a student whether he would be interested in majoring in chemistry or physics, and find that he has no conception as to what the adviser is talking about.

This avoidance of disciplinary subjects in our high schools is not simply a matter of laziness. Actually, our present high school practices strongly tempt our most ambitious and intellectual students to avoid such subjects. We place a great deal of importance upon grades. Our more selective colleges are only

A. Devaney, Inc., N.Y.

. . . the skilled mechanic, next door, spends his evenings watching television programs.

interested in the high school students who have graduated with the highest scholastic averages. There is a very great temptation for the scholastically ambitious student to avoid those courses which he knows are most difficult in order to boost his scholastic average. I know it is true that the standard practice in each course is to adjust the grades so as to give the same distribution between *A's* and *B's* in calculus as are given in art appreciation, but any student knows that the mental caliber of the students in the calculus class represents tougher competition than the average mental caliber of the students in the art appreciation course.

To point up the seriousness of this situation, let me give you a few specific examples.

Through my sons, I have followed the development of a young man of excellent mental ability who

H. Armstrong Roberts

. . . the worker, whose responsibilities end when he punches the clock on his way out, spends his week ends at a lake.

is now a student at one of the Ivy League colleges. In preparatory school he had his heart set on going to one of the Ivy League colleges, but to do so he had to have the financial assistance of a scholarship. I know that throughout his preparatory school course he carefully selected, as far as possible, only those subjects in which he thought he had the best chance of getting the highest possible grades. He got the scholarship, but studied only the absolute minimum of mathematics and science in his preparatory work.

Another case is that of the son of an engineer friend of mine. The boy had gone through high school intending to be an engineer. He was in friendly scholastic rivalry with three of his friends who were going to specialize in business administration. His particular high school offered two senior courses in mathematics: one a special intensive course for prospective engineers, and the other a much easier and more generalized course for prospective liberal arts students. He took the engineering course; his friends took the generalized course. There was no question about his being a better mathematician than his friends; but, due to the greater competition in the specialized course, he got a *B* whereas his friends got *A's*. They graduated *cum laude* as a result and he did not. All four of them are now studying business administration.

One of the best of our smaller strictly liberal arts colleges requires two years of a generalized science course for graduation. The course is divided into two sections: one is a specialized course for science majors, and the other a generalized course adjusted to represent the minimum of scientific knowledge which they feel a liberal arts graduate should have. A few years ago they had a near rebellion among the students in the generalized course. They threatened to go on a strike because the work was too difficult and too many of them were failing. All this happened in a college which accepts for entrance only students with top high school grades. I understand unofficially that now this school, before admitting students, goes beyond their generalized scholastic average to make sure that they have a record in mathematics and science which will insure their ability to successfully carry at least a minimum college science course.

Recently I was talking to the assistant head of the home economics department in one of the teachers' colleges. She said the college was having difficulty in getting girls who will specialize in home economics because the course includes a certain amount of chemistry. In addition, students who do select home economics have difficulty in getting through the chemistry course largely because they are almost all highly deficient in mathematics preparation.

It would be highly unfair, however, to our young men to imply that their decisions to avoid mathematics and science are based entirely upon what is easy or expedient. If you talk to students in high schools or colleges, you will be impressed by the fact that their selection of courses is greatly affected by their opinion of the teachers giving the course. The kind of intelligent, ambitious people we need in science and engineering are very likely to choose a tough course if they feel the teacher is interesting or particularly good. There is justification, therefore, for believing that the greatest difficulty with our high school situation is the steady long-range deterioration in the caliber of the teaching of science and mathematics in the secondary schools due to the difficulty of getting and keeping adequately trained teachers of science and mathematics. If our high schools were adequately staffed with teachers who had a sound training for science – and the personality to make students see the fascination which science and mathematics can have for an educated mind – we would not have to worry about the fact that other pressures were tending to drive even our ambitious and intelligent students away from these courses.

The difficulty of keeping the high schools supplied with properly trained science and mathematics teachers is the inevitable result of a long-range economic trend which there seems little likelihood of reversing. A man who would meet the specifications of a really capable and inspiring high school teacher of science also exactly fits the urgent needs of our scientist-hungry industrial machine. There is a very wide differential, salary-wise, between the industrial opportunity and the teaching job. There is no reasonable possibility of either reducing the financial attractiveness of the industrial job or of raising the financial inducement of the teaching job to match that of the industrial position. School boards are almost unanimous in feeling that they cannot possibly pay the science teachers more than they pay their other teachers with university degrees. With the growing problem of providing schools for the mounting student population, there seems no reasonable likelihood that school taxes can be raised to the point where *all* high school teachers can be paid salaries comparable to what industry is paying graduate scientists. The high schools cannot pay a qualified graduate scientist any more than they feel justified in paying a young woman seeking a three-year or four-year job before she gets married. Therefore there seems little practical likelihood of solving our high school science problem by a radical and overall improvement of the caliber of the people teaching science in the high schools.

There will always be some splendid science teachers in our high schools and one must speak words of praise for the industrial companies and other organizations who are trying to make the lot of these high school teachers of science more attractive by summer jobs, plant visits, and a variety of other efforts. However, as long as the major economic incentive draws scientific men to industry instead of to the secondary schools, we can only expect a worsening of the present situation where more and more science and mathematics courses are being taught by people with no specialized training in these subjects.

There are, however, three things which it should be practical to do and which should go far toward solving the problem of creating, in our high schools, a situation where a proper number of qualified students become interested in and prepared for scientific and engineering careers. Fortunately, all three of these things can be done by industry without getting involved in local school board politics or raising

(*Continued on page 370*)

M.I.T. Photo

In addition to the general science subjects, with major emphasis on physics and chemistry, students desiring to follow careers in medicine may receive thorough training in the life sciences in M.I.T.'s Dorrance Laboratory of Biology and Food Technology.

Union of Medical and Engineering Education

By JAMES HOWARD MEANS

DURING my entire professional life I have participated, one way or another, in the educational process of medicine. Now, in the five years I have been at M.I.T., I have also had the opportunity there to observe from the sidelines, some of the features of the education of the engineer. Certain indications and requisites common to the two have impressed me, and I believe the identification of these, and the relation of each to the other, may increase our understanding of both.

First, I submit that neither medicine nor engineering is a science in its own right. Both are professional callings with definite practical objectives to reach which will make use of any knowledge, method, or facility, whether scientific or other, that helps to serve their ultimate purpose. Both the engineer and the physician must rest his practice on a strong foundation of scientific fact and theory. In the application of these to vital human needs, however, both must gain understanding of human behavior and its motivations, not only in the individual, but as reflected in the community as well. Finally, in order that the professional person may be able to circulate freely among, and communicate with, intelligent and well-educated people, it is imperative that he himself have the benefit of at least a modicum of good general education.

The personal qualities of detachment, the ability to make value judgments with integrity, to reach wise decisions, and to carry through, responsibly, courses of action derived therefrom, are the essence of what it takes to make either the good engineer or the good physician. Such qualities can be the fruit of an education which gives experience in the moral as well as in the material components of our living.

With these points of similarity between present-day medical and engineering education in mind, let us look back for a moment at the pathways of their evolution. We shall find that although they now are running in somewhat close parallelism, their origins were far removed from one another.

Medicine emerged originally as a function of the priesthood. Born of the desire to bring to bear upon the physical and mental suffering of mankind, the healing power of deity, only subsequently did it become, in part, scientific in its nature. On the other hand, from its very beginnings in the dawn of history, engineering must have been scientific at least to the extent that it required some knowledge of quantitative principles in order to accomplish its practical purposes.

It is more recent history, however, that concerns us in this present analysis. From the era of the Renaissance onwards, one finds medicine progressing as a practical art, illuminated from time to time by flashes of scientific insight, and gaining steadily in respectability and social status, until it took its place beside law and theology as one of the learned professions.

Massachusetts General Hospital

A practical example of the union of medicine and engineering is shown here as Gordon L. Brownell, '50, Ph.D., physicist at M.I.T. and the Massachusetts General Hospital (left), works with John B. Stanbury, M.D., physician at the Massachusetts General Hospital and the Harvard Medical School, making use of radiation to solve medical problems.

As such, medical education became an altogether proper function for the great universities, and for the most part faculties of medicine have become university faculties. Not so with engineering, which receiving no corresponding academic accolade, has been obliged to develop its own independent system of education. This it has done by creating its schools and institutes of technology, which in turn, in the course of their evolution, have now come close to full university stature. It was early recognized that engineers, no less than other professionals, need general as well as vocational education. Therefore, in order to provide this, the engineering schools have added unto themselves all those disciplines which are necessary to give it.

Not having originally penetrated the fold of the traditional university as had medicine, engineering has made its own near-university fold for itself. Thus medical and engineering education, starting far apart, have subsequently drawn together in some important fundamentals, and this fact packs a challenge which is quite worth identifying.

In brief, the great schools of technology of today have actually become, as James R. Killian, Jr., '26, President, has said, universities polarized around science. They have reached the point of being proper breeding grounds for any of the professions which render a skilled service to the community requiring a firm and broad foundation in the basic sciences. The list includes not only all the subspecies of engineering, but architecture, industrial management, and at least a portion, of medical education as well.

As a matter of fact, M.I.T. has been giving premedical education almost since its very beginning, or at least after their undergraduate years, certain of its alumni have had no difficulty in being accepted by medical schools. Only very recently the Institute has issued an attractive brochure entitled "Premedical Programs at M.I.T." This proclaims that "over 400 physicians now practicing in the United States took their premedical work at M.I.T., and currently a dozen or more M.I.T. seniors each year enter leading medical schools in the United States and abroad." I got part of my own inspiration to study medicine when I was a special student in biology under the late Professor William T. Sedgwick in the academic year 1902–1903 "when M.I.T. was Boston Tech," and Samuel C. Prescott, '94, Professor of Industrial Biology, Emeritus, was one of my teachers!

The premedical brochure makes the point that there should be no set premedical course. Medicine needs people with many different kinds of background and preparation. The "quality they must all have in common is breadth, as well as some depth, in learning." The same can be said of engineering.

In April, 1948, I had the privilege of attending an interprofessions conference on education for professional responsibility held at Buck Hill Falls, Pa. The guiding genius of this meeting was Elliott Dunlap Smith, Provost of Carnegie Institute of Technology. The professions he called together were law, medicine, theology, engineering, and business administration. The avowed purpose was to compare the objectives, methods, and human relations of these several disciplines in order to derive principles which determine professional and social responsibility in all of them. It is interesting that of the five professions chosen, three are of the group of old learned professions, and two are, relatively, newcomers. From its inception, M.I.T. has served engineering and, more recently, business as well. Moreover, the Institute also seeks to provide the opportunity for its students to acquire that broad background of learning so necessary in all professional work.

The gist of the Buck Hill Falls deliberations was that professional education must inculcate the recognition and acceptance of responsibility in professional matters, and that in company with general education, it must participate in preparing professional students for "effective citizenship and cultivated living" as well. It was believed desirable that general education and professional education be so related to one another that these values can be attained "without allowing four college years to elapse before education takes on the vitality and usefulness that it could have from the start." For the very reason that it has been obliged to develop its own educational system, engineering alone, of the professions under discussion, has succeeded to some degree in effecting such educational integration.

As one looks at professional education other than in engineering, it is at once apparent that a sharp dichotomy exists between the general education at the college level and the professional education at the graduate level. Very often the two are given in different institutions – always they are given by different faculties. Beyond the fact that certain subjects are required for admission by the professional schools at the college level, in practice there is but little educational continuity between them. For the student in a liberal arts college who looks forward to a career in medicine, the struggle to get into medical school itself creates a veritable obstacle to the attainment of the educational integration which would seem so desirable. The term "premed" discloses what I mean.

At the college level, requirements for entering the medical schools are largely basic science, and therefore (if entered in the right spirit) a proper part of well-conceived general education. Entrance requirements in the premedical schools, however, may become reduced to mere leverage subjects, in which excellence is sought by the student, not for purposes of general education, but for the ulterior one of getting him into medical school. These premedical subjects may indeed become merely inclusion bodies in the liberal arts program, unrelated to the rest of it. But they may also undermine such a liberal arts program, converting it from true general education to prevocational training. Instead of rejoicing in the opportunity for general learning (of which science is a normal part) the college student headed for medicine already regards himself as a professional person – a "premed" – and the only responsibility of which he is conscious is that of equipping himself for that single discipline. The label "premed" itself may impose something of an educational strait jacket. I have had undergraduate students say to me that they would like to profit by the wealth of opportunity afforded by a liberal arts program, but cannot afford the time and effort necessary to do this, because getting into medical school is their primary objective, and for this one must earn high marks in physics and chemistry.

In engineering schools professional education has always begun at the undergraduate level, and many an engineer has entered the practice of his profession upon completion of the undergraduate course. A situation of this kind is equivalent to entering medical school directly from secondary school, and starting the practice of medicine immediately after graduating from it. Such a sequence has, to be sure, occurred in the past, but now it is no longer permitted. A minimum of two years – and more usually three or four – are spent at the college level before entering medical school.

The undergraduate student in an engineering school is in no such potentially frustrating position as is the premedical student in a liberal arts college. Unlike the premedical student who has a struggle ahead of him to gain entry to his professional school, the student of engineering is already in. Along with his professional training a modicum of general education is also offered the student of engineering; indeed at times it may be forced on him.

As educational evolution has progressed, however, the tendency has been for ever more engineering students to elect to stay on for graduate studies leading to advanced degrees in engineering. In this respect engineering and medical education have drawn together. But there is an important difference. In engineering there need be no change from one school to another; in medicine, the student transfers from a faculty of arts and sciences (with little interest or understanding of medicine) to a faculty of medicine with a similar lack of interest in general education. Engineering thus escapes the dichotomy of medical education. In training engineers, general and professional education can flow along together uninterruptedly from Freshman year to the doctorate, and the possibility exists of relating the two meaningfully, although consummation is as yet far from complete.

It is time, now, to disclose the point of the analogy which I have been attempting to draw between engineering and medical education. Briefly it is that having developed their departments of basic science to a high degree of excellence and distinction, having greatly enriched their schools of humanities, and having become in fact "universities polarized around science," engineering schools are now uniquely qualified to expand their contributions to medical education. Although "institute of technology" remains their generic name, they are in fact educating career physicists, chemists, biologists, economists, architects, and industrial managers as well as engineers. Since institutes of technology offer, in very fine quality, most subjects needed to educate physicians, up to what is called the clinical level, why should they not now appropriately add this band to their already broad spectrum of professional education?

Recently I asked a member of M.I.T.'s Class of 1956, who has already been accepted by a leading medical school, when he made up his mind to go into medicine. He replied that it was in his high school days. I then asked why in that case he chose M.I.T. for his undergraduate education. "Because it excels in its basic science teaching," was his answer.

The reasons for claiming that institutes of technology are uniquely equipped to participate in medical education have already been partly indicated. The excellence of basic science is one, the avoidance of a confusing dichotomy between college and professional school education is another. The possibility of continuing under a single faculty up to the point of clinical application is very appealing to me. I believe it would permit the achievement of that meaningful relationship between general and professional education, and the development of the sense of responsibility, both professional and to the community, which the Buck Hill Falls conference regarded as prime desideratum.

With doctorate degrees in both medicine and biophysics, Myles Maxfield, '50, Assistant Professor of Biophysics, is well qualified to direct the training of M.I.T. students who ultimately wish to follow careers in medicine.

M.I.T. Photo

I also believe that expansion of the educational function of an institute of technology into the medical field would benefit its whole operation. The intermingling of students headed for a variety of professions, but having the common need for firm grounding in basic science, is of itself of high educational value. The introduction of a medical element would enhance this process still further. Some subjects now taught, at least at M.I.T., would be peculiarly enriched by closer contact with medicine.

Actually, of course, M.I.T. has collaborated in medical activities on several fronts for a long time. Professor Robley D. Evans of the Department of Physics, for example, studied radium poisoning with Dr. Joseph C. Aub at the Huntington Memorial Hospital as early as 1934. Then in 1937 with the advent of radioactive iodine, Evans began a series of investigations in co-operation with medical investigators which has continued with broadening scope ever since. The application of radioactive iodine to problems of the thyroid gland, studied jointly with members of the Thyroid Clinic of the Massachusetts General Hospital, seems to have been the first use of radioactive isotopes in medical research. In passing, it is worth noting that it was the promise of this early work with radio iodine which made it possible to raise the money with which to build the cyclotron at M.I.T. A great expansion of isotope work by the Institute and the teaching hospitals of Boston has taken place since those days. During World War II, Evans with Aub, and the late Soma Weiss, used radioactive isotopes of iron in studies on the preservation of blood for the Armed Forces, and after the war, with Ivan Frantz in studies on proteins with radioactive carbon. Later Gordon L. Brownell, '50, research associate in the M.I.T. Physics Department working at the Massachusetts General Hospital, used radioactive arsenic for the localization of brain tumors. It is no exaggeration to say that the use of radioactive isotopes has greatly widened the frontiers of medicine. In this development, M.I.T. has played a pioneer and essential role. The pioneering work in the use of radioisotopes represents a fruitful union of physicist and physician.

In the field of high-voltage x-ray therapy, the treatment station of Professor John G. Trump, '33, operating in collaboration with the Lahey Clinic and within the Department of Electrical Engineering, constitutes another M.I.T. excursion into medicine, likewise pioneering in character. In this case, patients actually come to the Institute for treatment.

Of course, the Institute has its own medical department, which not only offers medical care to students, faculty, and employees, but also participates informally in the educational process from the psychological point of view, and at the research level in certain problems of preventive medicine. Within the Medical Department, Dr. Harriet L. Hardy, Assistant Medical Director, has built up an occupational medicine sub-department, which has become very distinguished. Not only does it have the duty of protecting the whole Technology family from the peculiar chemical and radiation hazards of the kind of work which goes on here – but it conducts research in these fields also. The Medical Department is not officially a teaching department, but its usefulness could be extended were it to become one.

In view of these impressive facts, I have in mind that M.I.T. might do much more in the medical field. Undergraduate students, working in the general area indicated in the premedical brochure, might be offered the opportunity to continue expansion of their M.I.T. training for an additional two years, studying those science subjects required for admission to the third-year class of medical schools. During this time, students in such a program could earn bachelor's and master's degrees. They would not necessarily be committed to medicine until well along in such a program. They might instead proceed toward doctorates in more basic disciplines – biochemistry, physiology, microbiology, or one of the behavioral sciences. Some fundamental knowledge of the action of noxious agents is very broadening in all these disciplines.

I have long thought that an advance could be made if a faculty of arts and sciences, and one of medicine, would collaborate to offer such a program, but the deep cleavage existing between these, and the frequent switching from one institution to another by students, make this extraordinarily difficult. But no such difficulty would arise were an institute of technology to offer such a program. It would be quite similar to what already occurs in England where students matriculate as Freshmen at Oxford or Cambridge, and stay there until they go to London for a couple of years for clinical training at one of the teaching hospitals. In contrast to the struggle to get into the first-year class of medical schools, students would have no difficulty at all in getting into the third. Many medical schools have capacity for more third- and fourth-year students, and therefore are eager to get good transfer students. Heretofore, the source of these has been the two-year medical schools like that of Dartmouth, for example. But many of these are extending their training to four years, and therefore are themselves absorbing much of the present supply of transfer students. If M.I.T. offered a program such as I have suggested, my prediction would be that its graduates would be avidly "snapped up" for the third-year classes of top-ranking medical schools. I would also expect them to be better prepared in some respects, at that level, than those who had come up the conventional ladder. Further, I believe that M.I.T. teaching of such subjects as microbiology, pathology, immunology and pharmacology, of itself would add new meaning to our existing subjects of biology, biochemistry, and biophysics, quite apart from its obvious utility in medical education. I have no doubt that engineering throws back to physics, or other basic sciences, challenges which otherwise would not have been recognized. So, too, does medicine; from its observation of disease, fundamental questions arise which might not otherwise have entered the head of student or teacher of basic science.

Finally, I would expect that, on the more human level, a medical function in our midst would contribute to the depth of understanding in our areas of social sciences, economics, and industrial management. If this proved true, it would be further justification for M.I.T. to participate in the education of those who serve the medical function.

SHORTAGE OF Engineers and Scientists

Five Possible Attacks on This Problem Are Outlined; All Will Have to Be Employed Vigorously So That the Nation's Technical Man Power Will Be Properly Trained

By JOSEPH W. BARKER

It is reliably reported that industry, government, and educational institutions have a present manpower shortage of not less than 35,000 engineers and scientists; the figure is more probably of the order of 50,000, and it may run as high as 70,000. This June we shall graduate about 23,000 in science and engineering, and before we get to June, 1957, with something between 23,000 and 25,000 graduates, losses from retirements and deaths will have brought the shortages back to about 50,000. This statement is predicated upon a continuation of business activity at the level of an annual Gross National Product of 400 billion dollars – the present rate at which business has leveled off after its recent rises. It is further predicated on the assumption that there will be no increase in the ratio of engineers and scientists to other employees. The estimate also allows for no increase in the number of teachers of science and engineering in our total educational system, from high school through university.

I have depended upon the most conservative estimates of professional economists for the statement that Gross National Product will rise to something more than 400 billion dollars, before leveling off in the last quarter of this year and will continue at about the 400 billion dollar annual rate for 1957. Of course, there must be some element of crystal-ball gazing in those predictions. There is some uncertainty in guessing whether or not the "cold war" will get hotter; whether it will stay at its present temperature, or will get colder. Whichever way our defense preparations go will certainly have an effect upon Gross National Product.

The assumption that there will be no increase in the ratio of engineer-scientist employment to total employment in industry is certainly overly conservative. In 1900, industry in the United States employed one engineer or scientist for every 250 employees; by 1950, this had increased to one for every 60, and it is still increasing. For example, in 1953, the General Electric Company is reported to have had one engineer or scientist for every 15 employees and today that ratio is nearer one to 10. In the aircraft industry it was one to eight in 1954. Every new technological development tends to increase this ratio. Every increase in labor rates moves industry closer to more automation and this, again, increases the ratio of engineers to total employees. Hence, my assumption that there will be no increase in this ratio by June, 1957, cannot but be extremely conservative in calculating what the shortage will be by June of 1957.

Our entire educational system, from junior high school through university, is presently suffering from a serious shortage in the number of qualified teachers in *every* field. In the high schools the shortage of qualified teachers is most acute in mathematics, physics, and chemistry. Teachers of the same subjects – plus engineering – are acutely needed in our colleges and universities. This shortage is aggravated by the simultaneous shortages in industry and government, since even starting salaries in industry, being higher than those in schools, tend to draw teachers with scientific or engineering training away from the schools. Yet, a lack of qualified science teachers in the schools tends to discourage students from selecting science and engineering as careers. We *are* in a vicious cycle.

When we consider what may be done to break this vicious cycle in order to secure more engineering and science graduates to fill the yearly demand and to

U.S. Steel Corporation

cut down the accumulated shortage, we find still other discouraging trends. For the past seven to 10 years, the percentage of high school students studying mathematics, physics, and chemistry has been rapidly declining. These high school studies are prerequisites for admission to engineering or science majors in most of our colleges. The free elective system so widely prevalent has made it possible for high school students to graduate without undertaking these rigorous and demanding subjects. The students have been encouraged to seek the easy way. In addition, the lack of enthusiastic, competent, and dedicated teachers of science has tended to discourage even those students who initially desired to pursue these science prerequisites for admission to engineering and science programs in college. Under such conditions, it is not difficult to see why graduating college classes in engineering and science have been declining since 1950, even in the face of the known high demand for engineers and scientists.

It also is true that, in the years immediately following World War II, the U.S. Department of Labor was anticipating a serious depression. This Office issued *Guidance Counseling Advice* (which became widely disseminated in the high schools) to the general effect that engineers and scientists would be in oversupply, due to the intensive war effort in training such men. Under the influence of this advice, high school guidance counselors discouraged students from attempting engineering and science careers. Now we are reaping the whirlwind of this misinformation. It was not until the fall of 1953 that engineering and science freshman enrollments in our colleges began to increase materially. It will be at least two years before these enlarged classes graduate to enter industry and teaching.

Industry's Stake

Since the quality of high school teaching of science has a marked effect not only on the numbers but also on the intellectual quality of the students entering college for science majors or engineering, industry should have a very large stake in seeking to improve teaching levels. But industry is competing with the schools for the limited number of graduates. For the most part, salaries of high school teachers are based upon a fixed scale which depends upon the number of years of teaching and the amount of credit in educational methodology, which the teacher has accumulated toward an advanced degree in education. The law of supply and demand is not permitted to enter the teaching salary scale nor is *quality* of teaching permitted to be a factor in salary. Industry, on the other hand, operates completely under the law of supply and demand. Starting salaries offered for science and engineering graduates rise as the demand exceeds the supply. At the present time, the industrial recruiting parties on our college campuses and the employment advertisements in every metropolitan newspaper are offering a minimum of $400 per month for graduates with a bachelor's degree. How can a public school system compete for these men and women when most school starting salaries are at the average of $300 to $325 per month?

Let me point out another very important group of statistics. College graduates are approximately 22 or 23 years old. This means that they were born about 1933–1934, when the birth rate for the nation was at a very low point; this was one of the effects of the great depression. This age group also suffered casualties in the Korean conflict and hence the remainder is numerically even smaller than normal for an equivalent birth rate. It was not until the later years of World War II that our national birth rate began its sensational climb to its present level. For instance, the average birth rate from 1930–1939 was about 2.4 million, but by 1954 it had climbed to 4.1 million, and is still tending upward. These increased birth rates have produced a wave of students presently crowding our elementary schools. Shortly, it will be pushing junior – and soon, thereafter, senior – high school enrollments to something approaching double the enrollments of 1950.

To furnish teachers for the public schools so that these vastly increased enrollments may be handled effectively is a vital and serious problem for the maintenance, alone, of our educational system without giving any leeway for *improving the quality* of education. These teachers must come from the smaller numbers in the preceding age groups and must be secured in the face of competition from industry. Do not for a moment minimize the critical problem facing your school administrators. They are in need of your sympathetic consideration and effective co-operation at this time.

Just to give you one more complicating factor, let me mention the centrifugal tendencies in our metropolises. Suburbs are springing up in ever greater numbers and at greater distances from the urban center as the automobile makes travel quicker. Suburbanization makes new school buildings a necessity and these become another demand upon the school tax dollar. Certainly, new school building needs are competing with teacher salary raises for parts of the tax dollar. And communities have already been forced to raise the school tax rate to heights which threaten community development.

Have I painted such a sad state of affairs that you despair of any solution? Certainly, I hope not. But we must face what seem to be the facts of the case. Now, let me try to give you some possible methods of attack upon these problems.

Five Methods of Attack

First of all, I believe that industry must re-evaluate its demands for scientists and engineers. Wherever possible, technicians must be used in place of junior engineers and scientists. Even where this type of employment has been shown to be valuable "on the job" training for young graduates of engineering and science, we cannot afford to be profligate when the demand so far exceeds the supply. We must use engineers and scientists only where no one else can properly perform the duties. Such re-evaluation might well reduce the demand somewhat.

Second, I believe our schools could well reconsider the "certificate for teaching" requirements. For in-

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West Coast Regional Conference

By DAVID O. WOODBURY

All Photographs by Peter Woodbury

Dwight C. Arnold, '27, President of the Alumni Association (left), presents to Donald W. Douglas, '14, citation for outstanding service to the country.

More than 400 M.I.T. Alumni on the West Coast attended a day-long Regional Conference held in Los Angeles on March 17, with an extra complement of wives and friends helping to jam the Banquet Room of the Hotel Ambassador for the evening festivities. The vigorous speech of James R. Killian, Jr., '26, President, on the improvement of engineering education was the principal after-dinner attraction. It was preceded by the presentation, to Donald W. Douglas, '14, of a citation for outstanding service to the country and the world. Dwight C. Arnold, '27, President of the Alumni Association, made the award. Mrs. Douglas, also present, received a set of eight M.I.T. Wedgwood bone china plates, designed by Samuel V. Chamberlain, '18.

The Conference, dedicated to the theme, "The Impact of Today's Technology," opened promptly at 10:00 A.M. in the hotel's large auditorium, with Samuel E. Lunden, '21, presiding. Mr. Lunden shared the rostrum with Anthony Thormin, '27, President of the M.I.T. Club of Southern California, in introducing Mayor Norris Poulson of Los Angeles. His Honor's dark suit was enlivened by a brilliant green tie, which he had worn, he said, as a greeting to his Irish friends in and out of the audience on this St. Patrick's Day of 1956. Mr. Lunden observed, after the Mayor's greeting, that the tie might also symbolize the "smog green" condition with which the city had greeted the large team of Institute visitors.

First speaker of the morning was Gordon S. Brown, '31, Head of the M.I.T. Department of Electrical Engineering, introduced by William H. MacCallum, '24, a former president of the sponsoring club. Dr. Brown regretfully announced that he was pinch-hitting for George R. Harrison, Dean of the School of Science, unhappily confined to a sickbed in Cambridge. With his unfailing, though gentle vigor, Dr. Brown gave the audience a rapid-fire discussion of automation, which he characterized as a horrid word, whose fascinating gadgetry often is confused in the public mind with its tremendous social and scientific implications. "Technology is an open-ended issue," was Dr. Brown's theme. Minor hardware, such as radio and television, he urged, are merely closed-ended details that will pass on to something better. He disagreed, also, with newspaper headline writers who insist that automation spells the "second industrial

William L. Stewart, Jr., '23, banquet moderator, in action at the West Coast Regional Conference on March 17.

From Extreme left: *H. Guyford Stever at lectern, and Hall L. Hibbard, '28, moderator; E. P. Brooks, '17, talks on management.* Above: *Mrs. D. O. Woodbury, Mrs. Fossett, Richard L. Fossett, Jr., '33, and Gordon S. Brown, '31.*

revolution." "If it is a revolution," he said, "it is an intellectual one."

Second morning speaker was Theos J. Thompson, Associate Professor of Nuclear Engineering. Dr. Thompson received the rapt attention of everyone in his description, illustrated by numerous slides, of M.I.T.'s new research reactor. Especially interesting was his statement that the time required to design the reactor had been shortened by at least two years by the use of the Institute's great computer, Whirlwind.

Both speakers were besieged with questions after their talks. Luncheon followed immediately, in the hotel's main ballroom.

Charles H. Toll, '23, chairman of this meeting, introduced Julius A. Stratton, '23, Vice-president and Provost of the Institute, who gave the Alumni a vivid description of the Lincoln Laboratory and its origins. Many of Dr. Stratton's listeners heard details on the Lincoln Laboratory for the first time, since its work has been highly secret. All members of his audience were on virgin ground when he showed the U.S. Air Force film, SAGE (Semi-Automatic Ground Environment). This was the first open showing on the West Coast of this exciting documentary film portraying the ultra-modern data-processing defense system, on which Jay W. Forrester, '45, and his associates have been working with the Armed Forces for the past five years. Many Californians hoped that an early descendant of SAGE would be installed somewhere near Los Angeles.

Following luncheon, the Conference moved straight from the film showing to the auditorium for the afternoon session, under the chairmanship of Hall L. Hibbard, '28. Mr. Hibbard, Engineering Vice-president of Lockheed Aircraft Corporation, was well chosen to introduce H. Guyford Stever, presently Chief Scientist of the Air Force, who next July returns to M.I.T. as Associate Dean of Engineering.

Dr. Stever left no doubt of the impact of today's technology in his telling demonstration that the engineering backlog of today in aviation will set the stage for tomorrow's technical advance. He discussed pressing problems, such as the air-traffic congestion, sure to accompany the adoption of commercial jet airplanes, the need for military aircraft that can take off and land vertically, and the very severe problems of nuclear propulsion in the air. Dr. Stever touched upon the satellite, which, he said, is no easy problem, but perhaps less difficult than the problems of intercontinental guided missiles. The usual question about flying saucers found Dr. Stever prepared with a quotation from George E. Valley, Jr., '35, Associate Director of the Lincoln Laboratory, leaving the questioner about where he started.

The slightly military flavor which had obtained all day was completely set aside by genial E. P. Brooks, '17, Dean of the School of Industrial Management. If possible, the remarks of Dean Brooks were even more closely followed than those of previous speakers, since virtually all of his audience were businessmen themselves. He outlined the origin and philosophy of the new School of Industrial Management and discussed the many problems confronting

(*Concluded on page 362*)

Left: (*in reading order*) *William H. MacCallum, '24, helped organize the Conference; Samuel E. Lunden, '21, presided at the morning session; Anthony Thormin, '27, introduced Mayor Poulson; and Dwight C. Arnold, '27, President of the Alumni Association.* At right: *Charles H. Toll, Jr., '23, chairman of the meeting.*

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

First Fellow for Advanced Study

EDWIN H. LAND, President of the Polaroid Corporation, has been appointed a fellow of the School for Advanced Study at the Institute, according to James R. Killian, Jr., '26, President of M.I.T. Dr. Land will be a part-time Visiting Institute Professor, devoting as much attention to educational and research activities at M.I.T. as his duties at the nearby offices of Polaroid in Cambridge permit. He is the first fellow to be appointed to the new School for Advanced Study, which will be inaugurated next fall. The School is being established to provide a means for the informal association of visiting scholars from all over the world with the M.I.T. Faculty.

Dr. Land is a native of Connecticut and attended Norwich Academy there, and Harvard University. He began his studies of the polarization of light while in college and established Polaroid Corporation in Cambridge in 1937 for the manufacture of optical devices employing the principles of polarization.

In 1932, Dr. Land announced at a Harvard University colloquium the invention of the first light-polarizing material in sheet form, which has subsequently been applied to sunglasses and camera filters, special ray filters and sighting devices for military instruments, "3-D" motion and still pictures, and non-dazzling automobile headlights. He is the inventor of the Land camera, introduced in 1947, which makes possible immediate development of photographs.

A recipient of many awards, Dr. Land was given the Hood Medal by the Royal Photographic Society in 1935; the National Modern Pioneer Award by the National Association of Manufacturers in 1940; the Rumford Medal by the American Academy of Arts and Sciences in 1945; and the Duddell Medal by the Physical Society of Great Britain in 1949.

Among the numerous professional groups to which Dr. Land belongs are the American Academy of Arts and Sciences, of which he was president in 1951, 1952, and 1953; and the National Academy of Sciences. He is a member of the Advisory Board of the Hoover Institute and Library.

Professor of Architecture

EDUARDO FERNANDO CATALANO, a noted Argentine architect, has been appointed professor of architecture at M.I.T., according to Pietro Belluschi, Dean of the School of Architecture and Planning. He will come to the Institute in the fall of 1956.

Mr. Catalano has had an active career as a practicing architect in Buenos Aires (1941–1950) and as a teacher of architecture in this country and Argentina. He is now acting head of the Department of Architecture in the School of Design at the North Carolina State College.

Before he went to North Carolina as a visiting associate professor in 1951, Mr. Catalano taught for a year in the School of Architecture of the Architectural Association in London, England. In 1946, after having received a master of architecture degree from Harvard University, he was appointed professor in the School of Architecture at the University of Buenos Aires. He has lectured at the Georgia Institute of Technology, Tulane University, and M.I.T.

Mr. Catalano received his undergraduate training in architecture at the University of Buenos Aires, and was graduated in 1940. While studying for a master's degree at the University of Pennsylvania in 1944, he was on commission from the University of Buenos Aires to study the curriculum in architecture of the United States and South America. His government also commissioned him in 1947 to study theater lighting and mechanical equipment.

Little Visiting Professor

HUGH C. LONGUET-HIGGINS, distinguished British investigator in the field of molecular theory and John Humphrey Plummer Professor of Theoretical Chemistry in the University of Cambridge, England, has been named Arthur D. Little Visiting Professor of Chemistry at the Institute for the current semester.

George R. Harrison, Dean of the School of Science at M.I.T., who reported the appointment, also announced plans for a series of lectures on the application to chemistry of modern physical theories of atomic and molecular structure to be presented by Professor Longuet-Higgins during the spring term. These lectures will be open to all chemists in the Boston area, as well as to the M.I.T. community generally.

Professor Longuet-Higgins is one of Britain's outstanding younger scientists. His training was received at Oxford University where, as a member of Balliol College, he took the M.A. and D. Phil. degrees. After research work on the theory of the structure of diborane and other fundamental molecules, he came to the United States in 1948–1949 as a research associate with the Laboratory of Molecular Spectra and Structure at the University of Chicago. From 1949 to 1952, Professor Longuet-Higgins was reader in theoretical chemistry at the University of Manchester, where he made notable contributions to the theory of solutions and the electronic structure of molecules.

In 1952 he was named professor of theoretical physics at King's College, University of London, a chair whose tradition dates back to its first incumbent — James Clerk Maxwell. In 1954 Professor Longuet-Higgins succeeded Sir John Lennard-Jones in the Plummer Professorship at Cambridge. He is a fellow of Corpus Christi College there.

He has served the British government and British industry in various capacities, and is a councillor of the Faraday Society. In 1951 the Chemical Society of London awarded him its Harrison Memorial Prize for the most meritorious series of research publications by a British scientist 30 years of age or under.

M.I.T. Photo

Important administrative posts at the Institute will be filled by the three M.I.T. Alumni pictured above. Left: *Philip A. Stoddard, '40, has been named assistant treasurer of M.I.T. He was formerly associate placement officer and acting director of the Industrial Liaison Office.* Center: *Vincent A. Fulmer, '53, an officer of the Industrial Liaison Office becomes acting director of the I.L.O.* Right: *Merrill J. Baumann, '52, who has been on active duty with the U.S. Navy, is to be one of M.I.T.'s Industrial Liaison Officers.*

In Administrative Posts

THREE appointments to important administrative posts have been announced. Philip A. Stoddard, '40, formerly Associate Placement Officer and Acting Director of the Industrial Liaison Office, has been named assistant treasurer of the Institute. Vincent A. Fulmer, '53, Industrial Liaison Officer, has been named acting director of the Industrial Liaison Office. Merrill J. Baumann, '52, who was graduated from M.I.T. in 1952 and has since served on active duty with the U.S. Navy, has been named as one of M.I.T.'s Industrial Liaison Officers.

Mr. Stoddard's appointment was announced in March by Joseph J. Snyder, 2–44, Vice-president and Treasurer of the Institute. In his new post, Mr. Stoddard will serve as a deputy of the Vice-president and Treasurer "on operations relating to the physical property of the Institute, the various services provided the Faculty and students at M.I.T., and the services – other than fiscal – furnished the Institute's research laboratories," Mr. Snyder said. In addition, he said, Mr. Stoddard will represent the Vice-president and Treasurer in the activities of the Industrial Liaison Program.

Under his new appointment, announced in March by Admiral Edward L. Cochrane, '20, Vice-president for Industrial and Governmental Relations, Mr. Fulmer will direct the activities of the Industrial Liaison Office, aimed to help keep participating companies informed of technical developments at the Institute and to express at the Institute the technical needs and interests of co-operating industrial organizations.

Mr. Baumann, whose appointment as Industrial Liaison Officer was also announced by Admiral Cochrane, will serve in this important program of bringing together industrial research and Institute technical developments.

Mr. Stoddard, a native and resident of Hingham, attended Hingham High School and Phillips Exeter Academy before entering M.I.T. from which he was graduated in 1940. After military service with the Third Armored Division in Europe during World War II and an administrative appointment at Ingersoll-Rand Company, Mr. Stoddard returned to M.I.T. in 1947. He then became assistant to the Executive Officer of the M.I.T. Instrumentation Laboratory.

He has since held other administrative posts in M.I.T.'s Division of Business Administration. He has been acting director of the Industrial Liaison Office since February, 1955, while its regular Director, William R. Weems, '35, is on leave of absence to serve on a technical mission to Korea.

Mr. Fulmer came to M.I.T. in 1949 after graduating *cum laude* from Miami University, Oxford, Ohio. After completing the course requirements and general examinations for the Ph.D. degree in industrial economics in June, 1951, Mr. Fulmer became a teaching assistant in M.I.T.'s Economics Department. During 1952 he was an instructor in the Economics Department at Williams College, and returned to M.I.T. later that year to become assistant to the Director of the Executive Development Program in the Institute's School of Industrial Management; he joined the Industrial Liaison Office in 1953.

Mr. Baumann, who joins the Institute staff as Industrial Liaison Officer, was graduated from M.I.T. in 1952, majoring in the Course in Business and Engineering Administration. Since then he has been on active duty with the United States Navy, recently serving as chief engineer of a destroyer, the *U.S.S. Stephen Potter.*

Before coming to M.I.T., Mr. Baumann received the B.A. degree from Colgate University in 1950 where he was active in many athletic and other extracurricular affairs.

New Corporation Life Members

◄ *Gwilym A. Price*

David A. Shepard, '26 ►

Harris and Ewing — *Ferdinand Vogel*

ELECTION of two life members to the Corporation of M.I.T. has been announced by James R. Killian, Jr., '26, President of the Institute. The new life members are: Gwilym A. Price, Chairman and President of Westinghouse Electric Corporation; and David A. Shepard '26, Director of the Standard Oil Company of New Jersey. Both had been term members of the M.I.T. Corporation since 1951.

Mr. Price, who became president of Westinghouse Electric Corporation in 1946 and chairman of the Board in 1955, is also a director of Eastman Kodak Company, Mellon National Bank and Trust Company, National Union Fire Insurance Company, Westinghouse Air Brake Company, and the Hanover Bank. Born in Canonsburg, Pa., in 1895, Mr. Price was graduated from the University of Pittsburgh Law School and admitted to the Pennsylvania Bar in 1917. He returned to the practice of law following World War I service as commander of the U.S. Army's 302d Heavy Tank Battalion, and in 1920 he became an assistant trust officer of the Pittsburgh Trust Company. A member of the Pennsylvania State Legislature in 1923 and 1924, Mr. Price rose from trust officer to president of the Peoples-Pittsburgh Trust Company before joining Westinghouse as vice-president in 1943.

Mr. Price holds honorary degrees from four colleges and is a trustee of the Carnegie Institute of Pittsburgh, the Carnegie Corporation of New York, Elizabeth Steel Magee Hospital in Pittsburgh, Allegheny College, and the Pittsburgh Y.M.C.A. He is a member of the Business Advisory Council for the U.S. Department of Commerce, president and director of the Zoar Home in Pittsburgh, and president of the Electrical Manufacturers Club.

Mr. Shepard, a Director of the Standard Oil Company of New Jersey, became associated with the Company as a research engineer immediately following his graduation from M.I.T. and has had wide experience with the Company's domestic and foreign affiliates. Born in Denver, Colo., in 1903, Mr. Shepard was awarded the degrees of bachelor of science (1926) and master of science (1927) in Chemical Engineering at the Institute. After holding positions as research engineer with Jersey Standard and with the Standard Oil Development Company, he served for many years as European representative of the Development Company.

During 1942-1943, Mr. Shepard was Petroleum Attaché for the United States State Department in London, and in 1943 was appointed a special foreign marketing representative in the United Kingdom. He served from 1947-1949 with the Anglo-American Oil Company, first as shareholders' representative and later as chairman of the board. Mr. Shepard returned to the United States in 1949 as executive assistant to the president of Jersey Standard, and became a member of the board of directors in 1951.

Arthur A. Blanchard: 1876–1956

ARTHUR A. BLANCHARD, '98, Professor of Inorganic Chemistry, Emeritus – a distinguished teacher, researcher, and author of important technical works in the field of chemistry – died at his Brookline home on March 25, 1956. His long and devoted service to M.I.T. extended from 1903 until his retirement in 1941.

Dr. Blanchard, a native Bostonian, was graduated from M.I.T. in 1898 and became an assistant in the Department of Chemistry. Two years later he received a fellowship for study at the University of Leipzig, Germany, where he was awarded the degree of doctor of philosophy. Upon his return to this country, Dr. Blanchard served for a year as an instructor at New Hampshire College, now the University of New Hampshire, before rejoining the Institute staff in 1903 as instructor in inorganic chemistry. He was promoted to assistant professor in 1908, associate professor in 1914, and professor of inorganic chemistry in 1931.

Author of numerous books and papers on scientific and educational problems, Dr. Blanchard also achieved renown for his research in the field of inorganic chemistry. He was a fellow of the American Association for the Advancement of Science and the American Academy of Arts and Sciences, and held memberships in the American Chemical Society, American Association of University Professors, New England Association of Chemistry Teachers, and the American Forestry Association.

Acceptance of Scientific Theories

PHILIPP G. FRANK, distinguished physicist and philosopher, and retired lecturer on physics and mathematics at Harvard University, has joined the Faculty of M.I.T. for the current term as Visiting Professor in the School of Humanities and Social Studies. In announcing the appointment, John E. Burchard, '23, Dean of the School, said:

"Dr. Frank is the acknowledged master today of that line of scientific philosophy which is known as logical empiricism and which has found widespread acceptance among scientists. Once the successor of Ernst Mach and Albert Einstein as Professor of Theoretical Physics at the University of Prague, Dr. Frank presents the scientific positivism as Mach created it, in its most advanced form; and his work has become the textbook of a whole generation of scientific philosophers. At M.I.T., he will teach a guest course on the acceptance of scientific theories."

Dr. Frank was born in Vienna, Austria, in 1884, became privatdozent of physics at the University of Vienna, where he received his doctorate in philosophy, and at the age of 28 succeeded Einstein in the teaching chair at Prague. He held this post until 1938, serving as Dean of the Faculty of Science in 1934.

After coming to the United States, Dr. Frank taught mathematical physics and the philosophy of science at Harvard from 1939 until his retirement in 1954. He is the author of numerous books, including *Einstein, His Life and Times, The Law of Causality and Its Limitations, Relativity — A Richer Truth,* and *Modern Science and Its Philosophy.*

Four Faculty Appointments

TWO Faculty promotions and two new appointments have been announced by Julius A. Stratton, '23, Vice-president and Provost of the Institute. Tau-Yi Toong, '48, a member of the M.I.T. staff since 1951, was promoted to associate professor of mechanical engineering; and George N. Hatsopoulos, '49, formerly an instructor in the Mechanical Engineering Department, was promoted to assistant professor.

New appointees to the Institute Faculty are: Merton C. Flemings, Jr., '51, Assistant Professor in the Department of Metallurgy; and Lucian W. Pye, Assistant Professor in the Department of Economics and Social Science.

Professor Toong, who was born in Shanghai, China, is a graduate of National Chiao-Tung University in Shanghai, and received the degrees of master of science and doctor of science in 1948 and 1952, respectively, at M.I.T. Before coming to the United States, he had seven years' engineering and managerial experience in China. In 1951 he joined the M.I.T. staff as an instructor in Mechanical Engineering, and in 1952 he was promoted to assistant professor. Dr. Toong is the author of numerous technical articles in the fields of combustion, heat transfer, and fluid mechanics.

Professor Hatsopoulos had been head of the Engineering Division of Matrad Corporation (New York) and instructor at the Institute prior to his appointment as assistant professor of mechanical engineering. A naturalized American citizen and veteran of the U. S. Army, Professor Hatsopoulos was born in Athens, Greece. He attended Athens Polytechnic before entering M.I.T., where he was awarded the degrees of bachelor of science and master of science in 1950, and the professional degree of mechanical engineer in 1954.

Dr. Flemings, Assistant Professor in the Department of Metallurgy, has returned to M.I.T. after two years as a metallurgist with the American Brake Shoe Company in Mahwah, N. J. He received the degrees of bachelor of science in 1951, master of science in 1952, and doctor of science in 1954 from the Institute, and held staff appointments from 1951-1954. Dr. Flemings is a member of the Foundry Educational Foundation, American Institute of Metallurgical Engineers, American Foundrymen's Society, Sigma Xi, and Phi Mu Delta.

Dr. Pye, who has specialized in Far Eastern studies, political science, and international relations, comes to M.I.T. as assistant professor in the Department of Economics and Social Science. He was graduated from Carleton College and, following World War II service in the U. S. Marine Corps, received his master's degree and doctorate at Yale University. From 1949–1956, Dr. Pye was instructor and assistant professor at Washington University, research associate at Yale, and research associate at Princeton's Center of International Studies.

Admissions and Translations

THE 316th dinner meeting of the Alumni Council was held on Monday evening, March 26, at the Faculty Club in the Sloan Building of M.I.T. Dwight C. Arnold, '27, President of the Alumni Association, presided. The Association's Secretary-Treasurer, Donald P. Severance, '38, reported seven changes in class affiliation and that 19 members of the M.I.T. staff and Alumni Council attended the Los Angeles Regional Conference on March 17. It was also reported that seven members of the M.I.T. family had visited seven M.I.T. clubs as far as Monterrey and Mexico City between March 5 to March 20.

In addition to the chairmen elected at the November 28 meeting of the Council, members of two Alumni Day subcommittees were announced as follows: *Luncheon Committee:* Garvin Bawden, '21, Francis B. Kittredge, '21, William L. Taggert, Jr., '27, William H. Carlisle, Jr., '28, Eric A. Bianchi, '29, William H. Dennen, '42, Donald A. Hurter, 6–46; *Ladies' Committee:* Mrs. Dwight C. Arnold, Mrs. E. P. Brooks, Mrs. James R. Jack, Mrs. Ralph T. Jope, Mrs. Robert M. Kimball, Mrs. Malcolm G. Kispert, Mrs. Donald W. Kitchin, Mrs. H. E. Lobdell, Mrs. Philip A. Stoddard.

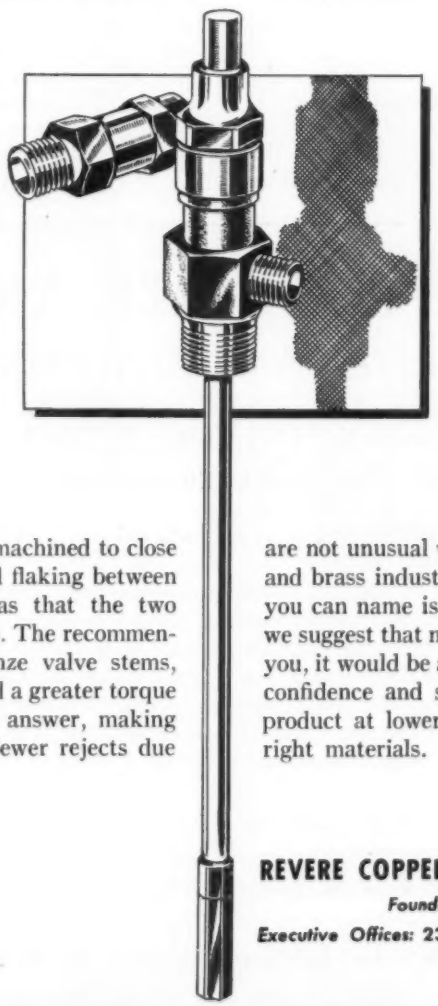
Dr. Egon E. Kattwinkel, '23, announced that the subject of the Alumni Day Conference, on the morning of June 11, will be "Science and the Health of Mankind" and will deal with the role of the scientist and the engineer in prolonging man's life. Those taking part in the conference will include: Dr. H. van Zile Hyde, Chief of the Division of International Health of the United States Public Health Service; Gordon M. Fair, '16, Professor of Sanitary Engineer-

(*Continued on page 358*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

In making gas pressure-reducing valves and relief valves for hot water tanks, a famous manufacturer has to drill brass rod deeply. Originally the rod was free-cutting brass. When we had the opportunity to study the operations in the shop it seemed evident that Revere's Deep-Drilling Brass Rod should offer some economies. When drilled, this alloy produces very small, easily cleared chips, much smaller than free-cutting brass. The latter is excellent for most applications, particularly for external machining, or for shallow drilling, but for really deep holes, deep-drilling brass is superior. So the customer agreed to try it. The results were most satisfactory. The shop foreman reported that tool life was increased over 200%. In addition, it is possible to bore one item with a single operation, against the former practice of withdrawing the drill three times in order to clear the chips.



Another interesting experience with the same manufacturer involves a high-pressure gas valve, with a cast brass body and a brass rod stem, both machined to close tolerances. There was galling and flaking between stem and seat. Our analysis was that the two brasses were too close in hardness. The recommendation: switch to arsenical bronze valve stems, which have a higher hardness, and a greater torque strength. This proved to be the answer, making possible a better product, with fewer rejects due to trouble at the seat. The more suitable alloy costs more per pound, but saves money in the end.

Here is a third example of our work with the same company. It was designing a new temperature-pressure relief valve for hot water tanks. The original model, hand-made for test purposes, had been machined out of solid hexagon brass rod, one inch outside diameter, and over half the weight had gone into scrap. It was recommended that on a production basis a Revere high-leaded brass tube be used, hexagon outside, round inside. A trial order of only 2,000 pounds immediately proved itself.

The customer reported that though the tube costs more per pound, he buys less weight per foot, machine time is reduced substantially, and a much better machined surface is obtained. The latter is extremely important on the inside of the valve, which is machined to a seat.

These examples of the wisdom of paying more per pound in order to make a better product and save money in addition are not unusual with Revere. Not only the copper and brass industry but practically every industry you can name is able to cite similar instances. So we suggest that no matter what your suppliers ship you, it would be a good idea to take them into your confidence and see if you cannot make a better product at lower costs by specifying exactly the right materials.

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THE INSTITUTE GAZETTE

(*Continued from page 356*)

ing, Harvard University; George R. Harrison, Dean of the Institute's School of Science; and Francis O. Schmitt, Institute Professor, Head of the Department of Biology at M.I.T.

Speaking on behalf of the Alumni Fund, Theodore T. Miller, '22, announced that contributions of $392,000, received up to March 26, exceeded by $156,000 those of the corresponding date two years ago, and are $56,000 higher than those of last March. Although last year's record is not expected to be exceeded, it is evident that the Alumni Fund is now operating at a higher level than in previous years.

President Arnold spoke briefly of the Western Regional Conference (reported on page 351 of this issue) where a certificate was presented on behalf of the Alumni Association to Donald W. Douglas, '14, "who, as a pioneer in the aircraft industry, has exemplified the roles of creative engineer and courageous business executive." Mr. Arnold expressed the belief that Regional Conferences represent one of the most valuable contributions by the Alumni Association to the Institute's external relations.

Upon conclusion of the business portion of the meeting, the 113 Council members had the opportunity to hear B. Alden Thresher, '20, Director of Admissions, speak on "College Admissions and the Tidal Wave of Students," and William N. Locke, Head of the Department of Modern Languages, and Director of Libraries, speak on "Machine Translation of Languages."

Since the end of World War II, there has been a great surge of applicants for college education. Applicants for admission to colleges have increased more rapidly than college facilities.

Each year there are about 15,000 to 20,000 potential applicants for admission to M.I.T. and about 5,000 of these submit applications or make some sort of inquiry. Approximately 4,000 complete all necessary forms required for admission, and from 1,800 to 2,000 are approved by the Admissions Office. Actually the entering class numbers about 900 each year. Thus, more time is spent in processing applicants for those who do not enter M.I.T. than for those who do, and the Admissions Office is engaged more in guidance and education of prospective students than in "recruiting."

In recent years, M.I.T. has sent Faculty members to various high schools throughout the country as part of this guidance program. Last year 37 members of the Faculty spent an average of about a week on this activity. The high schools welcome such guidance counseling and the Faculty members obtain firsthand knowledge of the problems of the Admissions Office at the high school level. In addition, some 600 to 700 Technology Alumni members of the Educational Council establish and maintain friendly relations with secondary schools and conduct interviews in various parts of the country to assist

(*Concluded on page 360*)

LANGUAGE, THOUGHT, AND REALITY

SELECTED WRITINGS OF BENJAMIN LEE WHORF

Edited and with an introduction by John B. Carroll

Foreword by Stuart Chase

xi + 278 pages Illustrated $7.00

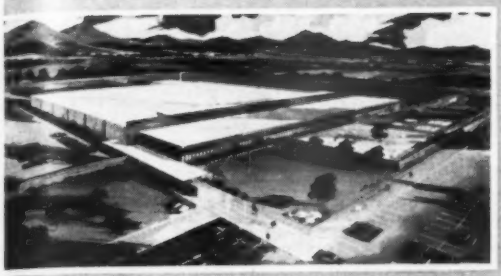
Once in a blue moon a man comes along who grasps the relationship between events which have hitherto seemed quite separate, and gives mankind a new dimension of knowledge. Einstein, demonstrating the relativity of space and time, was such a man. In another field and on a less cosmic level, Benjamin Lee Whorf was one, to rank some day perhaps with such great social scientists as Franz Boas and William James.

He grasped the relationship between human language and human thinking, how language indeed can shape our innermost thoughts. – Stuart Chase

Whorf's memorable Technology Review essays as well as important hitherto unpublished papers are included in this significant volume published jointly by John Wiley and Sons, Inc. and

The Technology Press of M.I.T.

AIRBORNE ELECTRONICS AND WEAPON CONTROL SYSTEMS



Denver manufacturing plant now under design

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Initial unit of flight test facility

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Simulators in computing center

At Ramo-Wooldridge today there exists a wide range of projects intended to aid aircraft in navigating to the vicinity of targets, finding the targets, destroying them, and returning safely to base. Work is under way in such fields as infrared and microwave detection, information display, communication and navigation, and analog and digital computing. Some projects are in the laboratory development stage, some in the flight test stage, some in pilot production.

Good progress is being made in the establishment of facilities and operational patterns that are well tailored to the unique requirements of advanced electronic systems work.

Positions are available for scientists and engineers in these fields of current activity:

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Guided Missile Research and Development
Automation and Data Processing
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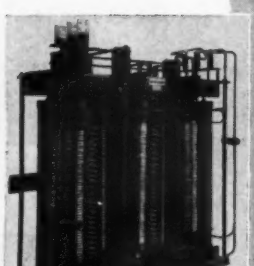

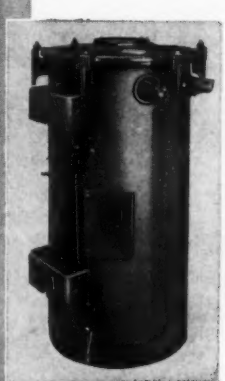

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Chester Meyer, '36, *Works Manager*

THE INSTITUTE GAZETTE

(*Concluded from page 358*)

promising students in their entrance to M.I.T. Last year 2,380 applicants from almost 1,000 secondary schools were interviewed, and 77 per cent of the entering Freshman Class was interviewed by Educational Council members.

The importance and magnitude of the task of translating technical copy was outlined by Professor Locke who stated that half of the world's scientific papers are now published in English and that this percentage is growing. The translating process can be considered in three separate steps: (1) transforming the spoken or written text into symbols; (2) translating the meaning of these symbols from one language to another; and (3) presenting the translated symbols into satisfactory written words in the second language. Computers and other modern devices appear to lend themselves to some form of machine translation. Computer mechanisms already existing or under development can handle the second step reasonably well, and they can be programmed to make a word-by-word translation, although the problem is not easy. Most computers can meet the third requirement by printing their output on tape.

Much work is being done in step one. A number of investigators in the United States and abroad are working on the problem of direct recognition of written or spoken text by a machine, not for translation but for commercial purposes. At least three companies are developing automatic check-reading machines for banks and one or more will soon be on the market.

A group of five scientists who are studying this problem at M.I.T. under the leadership of Victor H. Yngve, Assistant Professor of Modern Languages, feel that word-by-word translation is inadequate and unsatisfactory. They are endeavoring to provide a more satisfactory kind of translation in which the meanings of the words are given greater emphasis than is possible by mere word-by-word interchange. This group is now engaged in an endeavor to write rules for making the information contained in a language syntax completely explicit. They hope, thereby, to find a better linguistic basis for translation by machine through the combining of such sets of rules for two languages. German and English have been chosen for the languages to be studied first.

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"PEOPLE are the Greatest Invention Yet"

Visitor to Telephone Company exhibit says: "The man of the house came out with a new reverence for engineering. I came out with a new reverence for people."

INTERESTED VISITORS—Pat Haan, a telephone accounting clerk, explains billing machine to Mrs. Beebe and her husband. "I was so impressed with everything I saw," says Mrs. Beebe, "that I went right home and wrote a piece for our local newspaper." It's so human and friendly that we are reprinting it here.

"We went to the Telephone Company's Open House," writes Evadne Scott Beebe in the Zion-Benton News, "and saw the electronic brain playing tick-tack-toe.

"My husband was enthralled with the performance but I was watching the deft, well-groomed hands of the woman displaying the machine. She wore a wedding ring and I wondered about her home and family.

"After we listened to her little speech we went to a man in a brown business suit who told us how telephone bills are made out. Then a clear-eyed young woman operated the machine for us. To be sure, it was an amazing gimmick, but not nearly so attractive as the girl who handled it so well.

"Outside we stopped by a truck with an 'earth auger' and other modern attachments. Explaining their uses was a big, jovial lineman.

"While we listened to an account of how fast the auger could dig a hole, I was looking at the man and thinking that here was the typical lineman, strong, alert, capable and kindly, a person who, in times of disaster, becomes a kind of unsung hero.

"My husband said, 'This is what I want to see,' as we went into the equipment building. Here we saw switches and relays, ringing machines, countless colored wires in patterns like quilt blocks, and listened to technical explanations.

"That is, my husband listened. I watched the men as they talked so intelligently and wondered where they live, who cooks their meals and irons their shirts, what their problems are, and if they were ever in love."

EVADNE SCOTT BEEBE,
Zion-Benton (Ill.) News

MANY OTHER EXHIBITS. In addition to Open Houses at telephone companies, there are many other occasions and places where the story of the telephone is brought to you. These include fairs, lectures, moving pictures and traveling exhibits. Everyone is welcome. Bring the children, too.

There is, indeed, a lot of wonderful equipment in telephone service. But it takes more than 740,000 Bell System men and women to bring it into being and make it work. And because more people are making more use of their telephones, the number of employees is growing all the time.

"People," as Mrs. Beebe points out, "are the greatest invention yet" in the telephone business.

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REGIONAL CONFERENCE

(Concluded from page 352)

young men going into business careers today. "Our main objective," he said, "is to teach students to think."

While Dr. Stever parried most of his questioners with the formula, "I won't answer that, but . . ." Dean Brooks continued so long that the meeting was not terminated until 4:30 P.M., with many queries still unanswered. For nearly an hour thereafter, Dean Brooks conducted a seminar for 10 to 20 people, who could not seem to absorb enough of his wisdom and charm.

After a rest period, which some used for going swimming in the hotel's pool, a large reception was held in the lobby of the Ballroom. If Southern California prides itself on its friendly interchange, none could have outdone Dr. Killian, who was seen everywhere, greeting scores of old friends and making new ones.

The banquet, which extended from 7:30 until after 10:00 P.M., was under the chairmanship of William L. Stewart, Jr., '23, whose humorous difficulties with introducing the long list of honored guests at the head table were, he said, due to the "script which was provided me."

Donald W. Douglas, '14, whose presentation (page 351) followed the dinner, reminisced of the days when M.I.T. was "Boston Tech" in the Rogers Building on Boylston Street. Mr. Douglas told the story of one of his company's vice-presidents, Arthur E. Raymond, '21, who was recommended to him by their mutual alma mater as good executive material. When Douglas asked M.I.T. how to contact Raymond, the reply was, "You will find him working in your stock room."

With Lee A. Du Bridge, President of California Institute of Technology, as an honored guest, Dr. Killian keyed his speech on engineering education in such fashion as gracefully to include M.I.T.'s sister institution. President Killian detailed some of the progress which the Soviets have made in attaining a first-rate research and engineering organization, directed toward the interests of the State, and compared these figures briefly with those pertaining to our own difficulties in the same field. While Russia's obviously efficient system might speed up the germination and development of ideas, he said, our own American system is still "the right one for us." Our objective must be to clean up our educational system and remove the roadblocks impeding it. "We must not be complacent," he urged, inveighing vigorously against the prevalent secondary school habit of the "guaranteed annual pass."

President Killian mentioned an anecdote about a cellist whose wife complained that he played only one note, while his colleagues seemed to finger their strings constantly. "They are looking for a note," the musician retorted, "I've found it." Carrying this theme along, Dr. Killian gave it point in his discussion of anti-intellectualism in our schools and warned of their attitude of condescension toward hard work.

Dr. Killian, however, assured his audience that M.I.T. had been re-evaluating herself thoroughly during the past 10 years. "Now, under the strain of peak demand for technical people," he said optimistically, "the Institute is ready to do its full share toward national survival in the age of technical conquest."

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SHORTAGE OF ENGINEERS AND SCIENTISTS

(*Continued from page 350*)

stance, retired engineers and scientists might well be willing to teach mathematics, physics, and chemistry in our high schools on a part-time basis if the certificate requirement for certain points of credit in educational methodology could be waived. I know many recently retired men who would be wonderful part-time teachers, drawing on their vast experience to enliven the course material with practical everyday examples. Part-time salaries, even at the present low teaching rates, would be a welcome supplement to the retirement pensions of such men. They would serve only a few years, but their service would come at the present critical phase in our problem. Retired engineers or scientists would create no additional retirement problem for the school pension system. This is a point where our educational administration could take rapid and effective remedial measures.

Third, in Bay City, Mich., there has been an important study of the practicality of using "teacher aides" to relieve teachers of those burdensome housekeeping duties which now consume somewhere between 20 and 40 per cent of teachers' time and energy. Financed by The Fund for Education, these experiments have shown remarkable results. Mothers who have college educations and whose family conditions permit have been employed part or whole time, not to teach, but to relieve the qualified teacher

(*Continued on page 366*)

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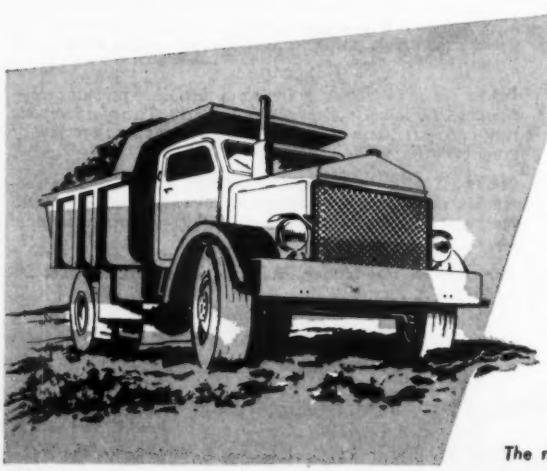

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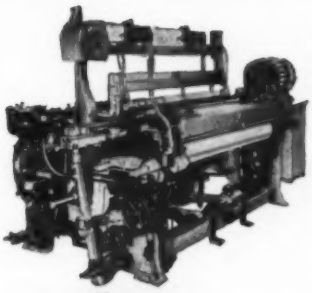

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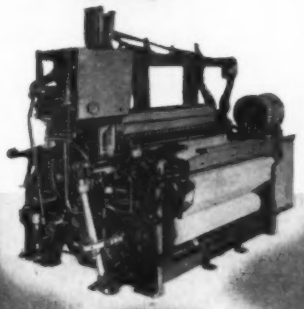

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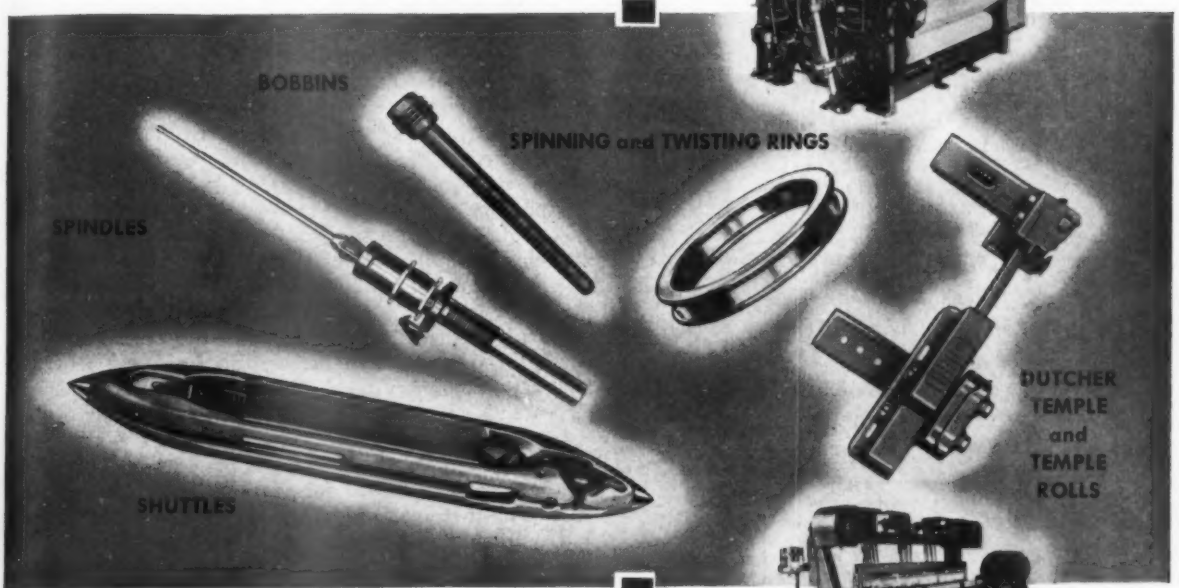
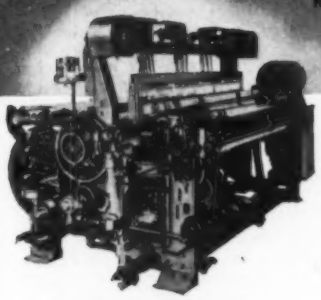
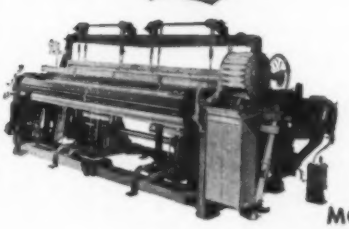




MODEL XP



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SHORTAGE OF ENGINEERS AND SCIENTISTS

(*Continued from page 364*)

of nonteaching duties. When the nonteaching duties have been assumed by the "aides," the teachers are able to take on additional pedagogical loads. Just as dental hygienists have taken over many dental details formerly loaded upon the dentist, just as "grey ladies" or "nurses' aides" have relieved the hospital shortages in registered trained nurses, just as receptionists and laboratory technicians have relieved the doctors of many time-consuming duties to relieve medical shortages, just so can "teachers' aides" help to relieve the teacher shortage.

Fourth, let me remind you that some 22,000 of the 28,000 high schools of our country have less than 500 students. Students in these small town and rural high schools deserve just as effective teaching as those in the large urban high schools. But how can a principal of such a small high school find the money in his budget to engage competent teachers in mathematics, physics, and chemistry? In Ohio, under the leadership of a prominent industrial scientist, one possible method of attack has been evolved. It is an adaptation of the "circuit rider" so widely used by our churches in the frontier days. To illustrate the modern application of this method, suppose there are three small high schools within 100 miles of each other. School A spends its science teaching budget for a mathematics teacher and a teacher aide, School B for a physics teacher and an aide, and School C for a chemistry teacher and an aide. Each teacher spends successive days in a different school traveling by car, while the teacher's aide keeps the records, corrects problems, supervises home rooms, cafeteria, and the like. There are possibilities of adapting this concept to many areas.

Fifth, a vast improvement and increase is possible in the use of audio-visual instruction, either by films carefully prepared by experts, or by closed-circuit television. In either case one truly experienced teacher could conduct the lecture and demonstration instruction in many schools simultaneously, while somewhat higher qualified and trained "teachers' aides" could supervise the problem work and some classroom recitations. Audio-visual films would have high initial, but low operating, costs, while closed circuit television would have both high first cost and

(*Concluded on page 368*)

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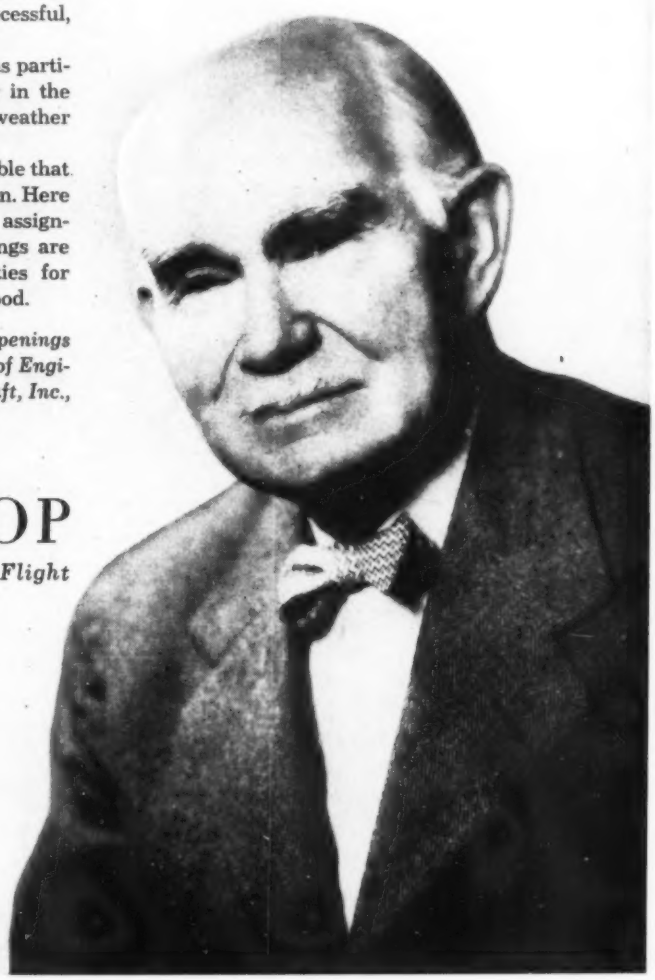

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SHORTAGE OF ENGINEERS AND SCIENTISTS

(*Concluded from page 366*)

high operating cost. The film instruction would tend to be inflexible, while the closed circuit television could be extremely flexible. Both would require curriculum content to be the same for all the schools served under this plan.

Conclusion

I have sketched out five possible attacks on these problems but let me state, as strongly as I can, that there will be no one, single, solution. Many M.I.T. men will have also heard of the "Lexington Plan" – originated by M.I.T. and Harvard professors living in Lexington, Mass. – and carried forward with the wholehearted financial and moral support of Arthur D. Little, Inc. Each locality will have unique problems requiring unique solutions. What works well in one place may fail miserably in another. What works well one year may lose effectiveness in another year.

But the crisis is upon us. Solutions must be found. And it is the genius of America and our Western civilization that individual free enterprise has always found some solution to every problem. Let us put our hearts and minds into finding the best solution for each locality to this industrial and educational shortage which confronts us.

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PRODUCING MORE TECHNICAL MAN POWER

(*Continued from page 344*)

school tax rates. They can also be done without involving unreasonable expenditures by industrial companies who might co-operate in carrying them out.

First, and most obvious, of course, is an intensified campaign to explain to high school students, at the beginning of their high school course, the attractive possibilities and the opportunity for personal satisfaction which may be found in science and engineering careers. If the young man starting high school can be persuaded that such a career is what he wants, he will not be diverted by the pressures and difficulties which stand in his way. The National Association of Manufacturers and the Engineering Manpower Commission of the Engineers Joint Council have been doing excellent work of this type, and their success is already being reflected in a gradually increasing enrollment in many of our engineering colleges. One must also say a good word for the science fairs being held in many cities through the co-operative effort of high school science teachers and local industries. There has been some fear that this type of activity might draw into science and engineering men who were not suited for this occupation, but the very difficulty of the courses would seem sufficient assurance that those who do not have

(*Continued on page 372*)

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What is the promise for a man about to enter the business?

"Actually, there never was a better time to go to work for New England Life. Our dynamic growth in recent years — 28% gain in new business in 1955 — our District Agency Development Plan, our superlative policy contract are three of several factors which should be interesting to the man considering a new career. I would suggest that such a man write directly to Vice President L. M. Huppeler, 501 Boylston Street, Boston, Massachusetts for further details."

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PRODUCING MORE TECHNICAL MAN POWER

(*Continued from page 370*)

suitable interests and qualifications will drop off to other pursuits.

The second thing which might be done is a much more ambitious project. If we cannot provide stimulating and interesting teaching of mathematics and science in the high schools by recruiting highly qualified teachers, then we should turn our attention to revising teaching aids and practices so that these subjects can be taught in an interesting, stimulating, and effective way by men or women who do not have specialized training in these subjects. This would involve a joint effort of the very effective National Science Teachers Association, the teachers preparatory schools, and publishers of textbooks and teaching aids, working in co-operation with industrial public relations people and other industrial and entertainment people acquainted with the techniques of visual presentation. Certainly it should be possible to devise a teaching procedure for science which would be more stimulating, more interesting, and more effective than having science taught from a traditional textbook by a man who has never studied science.

This project must involve a basic change in the philosophy of teaching mathematics and science in the high schools and not simply be concerned with grafting movies and television onto the present teaching methods. In the old days, high school teaching was concerned, to a considerable extent, with training the mind. Now its emphasis has shifted to giving the student information he can use. The teaching of science and mathematics has not been readjusted to conform to this new concept. The modern high school student may be interested in how to determine the area of a circle but he has very little interest in how the formula for determining this area was developed. Our textbooks need to be revised; they should begin by emphasizing the practical usefulness of the subject being taught. Once the student's interest is aroused, he can then be led into the more abstract theoretical aspects. A project for modifying science teaching methods with the objective of making a fundamental change in approach would, of course, naturally use motion pictures, television, and other visual aids as an integral part of new teaching methods.

This joint effort should also direct attention toward some change in scholastic gradings, both for high school honors and for college admission, which will give proper relative weighting to grades secured in difficult and highly competitive courses as compared with those secured in the simpler and easier courses.

The third thing which might be done is to provide more direct incentives to increase interest in the study of mathematics and science in our high schools. In other words, we might take advantage of the good old-fashioned idea of selecting a very luscious looking carrot and then holding it close enough to the

(*Continued on page 374*)

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PRODUCING MORE TECHNICAL MAN POWER

(*Continued from page 372*)

donkey's nose so it will have some effect upon his behavior.

In its simplest and cheapest form, this might involve offering special prizes and awards for high school students doing particularly good work in mathematical and scientific subjects. The Westinghouse Electric Company, for example, is already doing an outstanding job in this connection. But the likelihood of achieving an award in the Westinghouse plan seems pretty remote to many of the people that we want to attract into the high school science courses. It might be better to provide prizes limited to the individual high schools which would involve honorable mention at the graduation exercises for those who have done outstanding work in science and mathematics along with those students who have done outstanding work in terms of general scholastic averages.

A much more direct incentive, however, would be a relatively large number of four-year undergraduate scholarships assigned to individual high schools to assist worthy students from low-income families to attend college, with the provision that they specialize in scientific or engineering fields. A proposal that industry shift some of its funds from direct support of general college activities to this more specialized approach would, of course, be greeted with no enthusiasm by college presidents. It would, however, be a way by which industry could be sure that its support of education was providing help where industry and the nation need it most. From the college's point of view, there should really be no objection to this procedure if the scholarships were accompanied by corresponding direct grants to privately endowed institutions which might be selected by the scholarship holder.

So far I have dealt primarily with the problem of seeing that a higher percentage of the young men sent from the high schools to the colleges go with an interest in, and adequate training for, scientific and engineering specialization. There is, however, of course a very considerable group of people who feel that the solution of the shortage of technically trained people is to increase over-all attendance in our colleges. It is commonly stated that 50 per cent of our best minds fail of their greatest usefulness because they are never college trained.

No one can take issue with the desirability of giving maximum training to the best minds in the country. One can, however, have considerable skepticism as to whether simply making higher education more easily available on a nonselective basis will achieve this objective. In view of the trends of student preference, one can be even more skeptical as to whether an increase in mass higher education would

(*Continued on page 376*)

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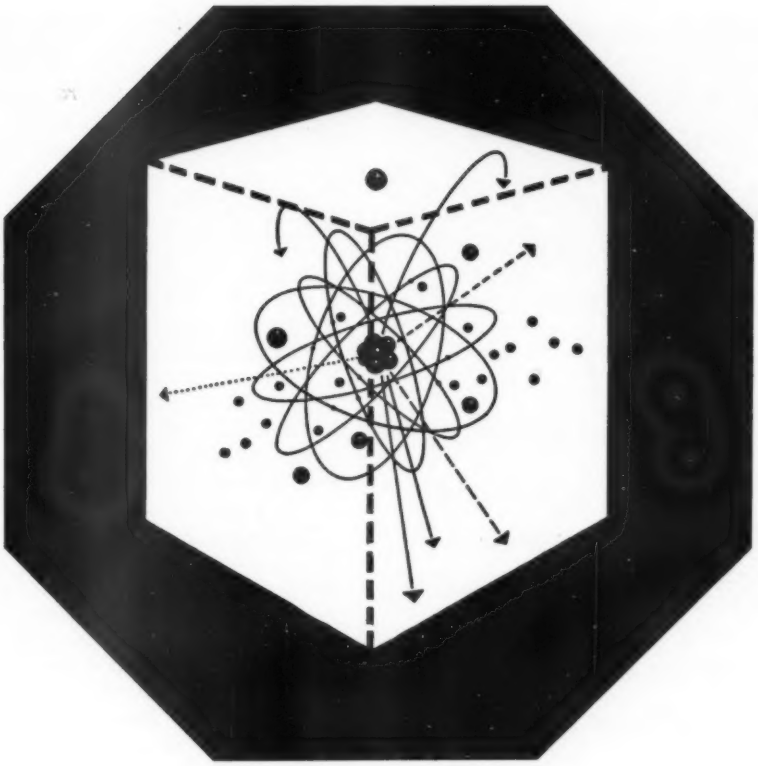

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PRODUCING MORE TECHNICAL MAN POWER

(*Continued from page 374*)

have a particularly large effect on the specific problem of the shortage of scientific and engineering personnel.

Any approach to the problem of getting a higher percentage of our best brains into the universities must face two situations. First, you have to create conditions in the high schools which will stimulate young men and women, particularly from the low-income groups, with a desire for learning and education. To do this, you must solve broadly the problem of providing inspirational teaching, which seems so impossible of solution in the scientific and mathematical field. Second, one must face changing economic trends, which are removing much of the economic incentive which used to make young men in lower income groups strive to attend college.

In the early 1920's, the most obvious way for a young man in a low-income industrial family to avoid hard physical labor and to escape from marginal living conditions to a satisfying living standard, was either to work his way through college or go through a trying and low-paid apprenticeship to achieve some skilled craft rating. To a very considerable extent, this pressing incentive no longer exists. No man with enough intelligence to secure a college degree needs to go to college in order to avoid earning his living by physical labor or in order to achieve a satisfying standard of living. Mechanization of industry and agriculture is largely limiting heavy physical labor to those men incapable of running machines. Ownership of a home in nice surroundings, a good automobile, paid vacations, enough money to travel, assured continuous employment, and an opportunity to educate one's children are all easily achievable without a college education.

It used to be said that, if a man did not train his brain, he had to earn his living with his muscles. He had to either think or labor. It may seem facetious, but still surprisingly true, that a highly satisfactory standard of living can now be achieved without either thinking or laboring. In our highly mechanized industrial plants, highly paid laboring men with no technical training normally perform highly repetitive operations which involve no great physical effort. It is the highly trained engineer who takes a brief case full of blueprints home to work on over the week end, and it is the scientist who spends his evening reading scientific literature, while the skilled workman living next door watches television or takes a trip to the seashore.

There is the very considerable question as to whether it is possible to attract into our universities the highly intelligent young men, from what we talk about as low-income groups, simply by making a higher education cheaper and easier to obtain.

Let us now consider for a few minutes the problem of how to insure our bright young men continuing to degrees in science or engineering even after we have gotten them to the university with adequate preparation.

(*Continued on page 378*)

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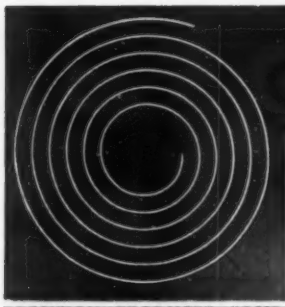

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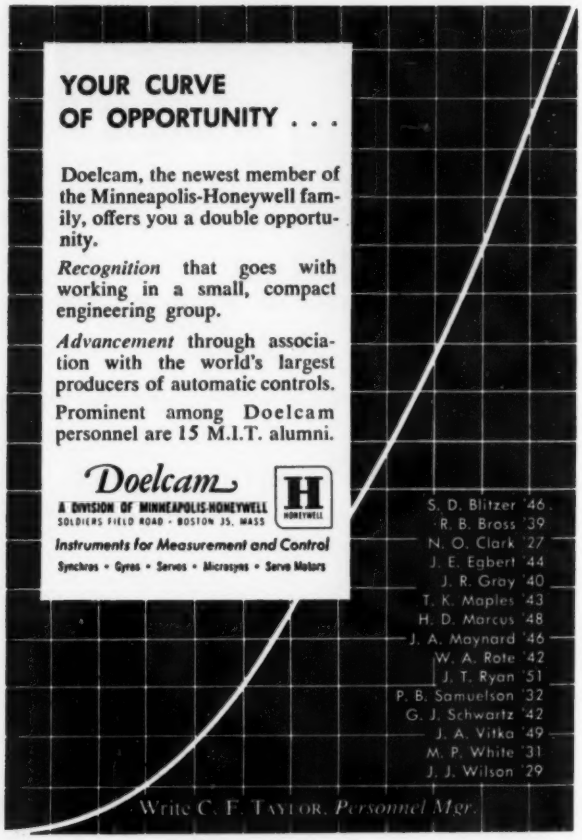
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PRODUCING MORE TECHNICAL MAN POWER

(*Continued from page 376*)

In the university, educational pressures very similar to those in the high schools tend to drive young men away from specialization in science and engineering. Again, scientific and engineering courses are the "tough ones." The engineers have to report early to get some of their work done before the liberal arts people arrive. Often they get less credit for a given course than do the liberal arts students because they must pack so much work into a four-year period. The science majors are almost barred from athletics and campus activities because of the long hours they must spend in the laboratories. Perhaps even more important, we have the same difficulty in providing inspiring science teaching, especially for the very large freshman classes. Too many of our potential scientists are discouraged from scientific careers by the fact that their freshman courses are difficult and not inspiring. Even our modern freshman chemistry textbooks concentrate the first freshman semester on difficult abstract conceptions of atomic structure. In too many cases, we are impressing college freshmen with the difficulty of acquiring a scientific education before we open up to them its interesting and challenging possibilities.

But, here again, there are plenty of men who have the intelligence and the perseverance to acquire

(*Continued on page 380*)

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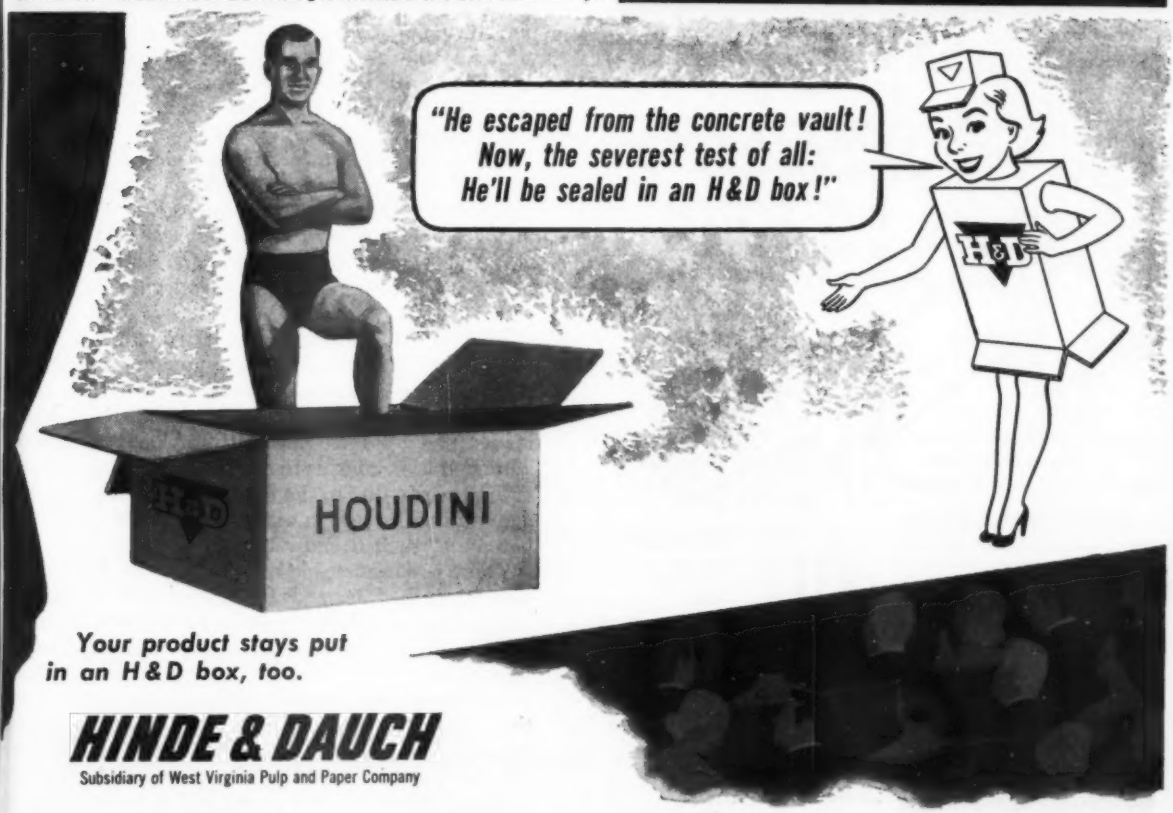

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(*Continued from page 378*)

technical degrees if they are convinced that the reward is great enough to justify the effort. Now, however, we are dealing with men who are thinking of rewards in much more realistic terms than scholastic prizes and scholarships.

We must face the brutal fact that, even among those going through college, science and engineering have not been of very high economic attractiveness. The laboratory scientist and engineers in industrial production were traditionally poorly paid all the way through the twenties, and thirties, and on into the forties. To be sure, the shortage of technical personnel during the past 10 years has rapidly raised the starting rate for technically trained people; but, to a very large extent, this rise in starting rate has been only partially effective in raising the salary standards of men already in industrial positions. Young men, particularly from low-income families, are likely to judge the economic attractiveness of a scientific profession by the living standard of the middle-aged plant control chemist in the factory where their fathers work rather than by starting salaries paid by research centers. In most cases, the difference between the living standard of the plant control chemist and the skilled mechanic is not sufficiently great to cause the young man to place a very high value upon a science degree. In considering the value of an engineering degree, he is most likely to explore what advantage the graduate engineers have in his father's plant in comparison with high school graduates. In most cases he is likely to find graduate engineers and upgraded skilled mechanics working side by side in industrial engineering positions with the same job classification and the same salary.

If industry hopes to persuade a very high percentage of the best brains from our low-income industrial families to strive for scientific or engineering degrees, they are going to have to put a larger and more obvious dollar value on the possession of such degrees on the part of the people who work in our industrial plants.

In most companies it is still true that the most likely route to high salaries and general management responsibility is through the sales department, rather than through the research or engineering departments. The rapid rise in the attractiveness of business administration courses to college students is probably at least partly due to the ease with which young men gain an understanding of this situation through their parents or their friends.

There is considerable reason for believing that industry supplied its needs for trained professional men during the early days of mechanization and industrial research from that class of people who went to college and took professional training because they came from family and income backgrounds which made this a more-or-less automatic educational choice. There is equal reason for believing that our 15-year-old shortage of scientists and engineers, which is now reaching its most acute stage, is due in considerable

(*Concluded on page 382*)

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(*Concluded from page 380*)

measure to the fact that industry's need for technical personnel can no longer be satisfied from this source. Now we must attract into these professions men who will only become scientists and engineers as their interest in these fields is aroused during high school days, and who can be carried through to technical degrees by incentives which make them feel justified in the special effort involved. Failing to do this, we may continue to see a higher and higher percentage of the mentalities we need in science and engineering turning instead to social sciences, business administration, and sales.

An adequate supply of scientists and engineers is essential both for our own economic welfare and for our safety in the cold technical war with Russia. We believe that our democratic system of free choice is better than Russia's dictatorship. However, in our civilization, it is often very difficult to achieve the balance of incentives which will cause a sufficient number of our people to do, of their own free will, the things which are essential for our national well-being.

The Russian system may be less effective in the long run, but it certainly has the advantage of simplicity and prompt action.

The Russians have decided that this is a scientific and mechanical age. They therefore feel it is important that their educated people have a thorough understanding of science. They are accomplishing this by the simple expedient of requiring that a considerable portion of the study time in their elementary schools be spent on science and a thorough grounding in mathematics. They specify that in their schools, which correspond to our high schools, 40 per cent of the students' time must be spent upon mathematical and scientific subjects. In Russia you cannot even achieve a high school education without a thorough grounding in the fundamentals of science.

The Russians have decided that this is a technological age in which industrial progress and national defense require a fully adequate number of trained scientists and engineers. They consider this so important that they are not content with their ability to assign students to engineering schools, and they are using the good old capitalistic technique of providing economic incentive. As a class, men with scientific and engineering degrees are the highest paid people in Russia.

Conclusion

We who pride ourselves upon our scientific and industrial leadership, need to take positive and effective steps to provide the kind of educational and economic situations which will produce an adequate number of scientists and engineers. It is equally important that we do something to counter the obvious trend in our educational system which tends in this age of science to produce an educated class which has less basic knowledge of science than the educated people of 20 years ago.

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A BOLD APPROACH TO MISSILE ELECTRONICS

a statement by **DR. L. N. RIDENOUR**, *Director of Research, Lockheed Missile Systems Division*

Electronics is central to the technology of guided missiles. Dramatic improvements in missile performance require faster, more accurate perceptions and reactions of electronic missile guidance and control systems.

Here at the Missile Systems Division of Lockheed, we are aware of this requirement. We also know that electronics is experiencing the greatest revolution in its history; the vacuum tube, hitherto the cornerstone of electronic design, is being replaced by new solid-state devices which have superior performance and reliability.

Thus the times favor a bold approach to missile electronics. Past techniques will not meet requirements of the future. Experience in old-fashioned electronics is no great qualification for the present challenge. By giving the broadest responsibility to scientists and engineers, we are trying to lay proper emphasis on the new electronics.

Lockheed **MISSILE SYSTEMS DIVISION** *research and engineering staff*

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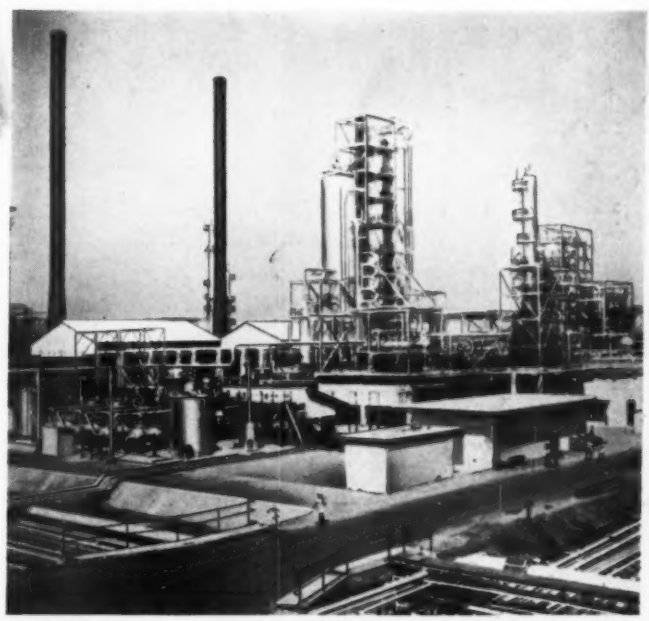
difficult physical conditions, but...

India's largest refinery was completed a year ahead of schedule



The 40,000 B/D refinery of Burmah-Shell Refineries Ltd. near Bombay, India is the country's largest. It is capable of supplying an estimated half of India's current requirements for finished petroleum. Although built in the face of difficult physical conditions, close cooperation with the owner in planning and engineering, and exceptional coordination of construction allowed Lummus to finish almost a year ahead of the original schedule.

A smoothly running refinery now, consisting primarily of crude distillation, fluid catalytic cracking, gas recovery, treating and blending units, offsite facilities and utilities, at the start it was only 450 acres of incredibly difficult terrain, without roads, railway or harbor.

Battling two of Bombay's worst monsoons, Lummus employed as many as 14,000 Indians at peak periods. Terrain was filled and drained. Roads, rail lines, harbor facilities, and the complete refinery were constructed. The job was kept moving *ahead* of the timetable – and finished 21 months from the start of construction.

A project of this magnitude requires a worldwide organization of experienced engineers and construction men able to cope with any problem. Lummus is such an organization and can design and build your next plant whatever the size, type or location.

The Lummus Company, 385 Madison Avenue, New York 17, New York. *Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pennsylvania. *Fabricated Piping Plant:* East Chicago, Indiana.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

to Engineers in Search of the Best Connectio

Type 938 Binding Post series is typical of G-R's extensive line of high-quality components. These posts are chosen by the leading manufacturers for their excellent electrical and mechanical characteristics and for their convenience and functional correctness.

Type	Description	Unit Prices *10-99	100-999	1000-1999	2000-9999
938-P	Metal top B.P. with metal spacer	$0.38	$0.33	$0.31	$0.30
938-WB	Black top, cone insulation	0.53	0.45	0.42	0.395
938-WR	Red top, cone insulation	0.53	0.45	0.42	0.395
938-L	Captive Shorting Link	0.10	0.09	0.085	

The basic posts, without cone insulators, are available from all of these assemblies. Cone insulators, grounding spacers and other parts are sold separately, also. Write For Prices.

*Minimum quantity sold. Prices net — no discount.

The replacement Type 938-Z Insulators fit 938 Binding Posts. Older Type 139 Posts used as well.

FEATURES

★ Polystyrene insulation throughout — cones hollowed to minimize solid dielectric

★ Dielectric Constant and Dissipation Factor low

★ High leakage resistance

★ Minimum moisture effects

★ Banana plug fits into body of post, NOT its top

★ Tops chamfered to seat banana plugs

★ All tops captive to prevent loss

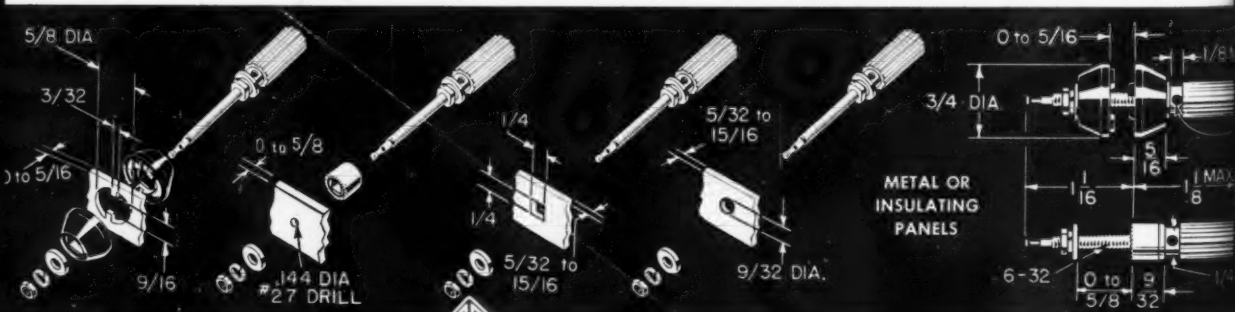
★ Solder directly to turret on mounting stud — not to lug under nut

★ Grounding post with spacer for proper height — flat knurl on bottom of spacer bites into panel and prevents rotation

★ Cross hole in top contoured for firm grip without shearing for any wire from A.W.G. No. 40 to No. 10 — tops will accommodate telephone cord tips, spade terminals, slende ligator clips etc.

★ Interlocking, anti-rotation k bases for any panel thickness fr to 5/16". If keying is not desired hole in panel frees key

★ Individual post-assemblies ad tageous in that pairs can be mou at any separation from the stan 3/4" to any spacing required — special parts needed.



Mechanical details of Type 938 Binding Posts and Assemblies.
Locking keys in 3/8-inch mounting hole can be omitted if locking feature is not wanted.

GENERAL RADIO Company

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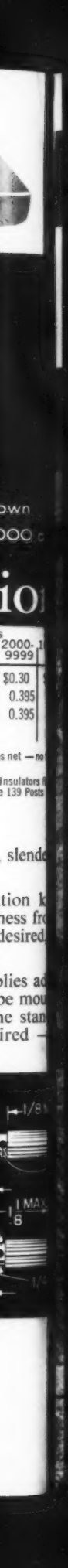
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